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Scientific critique- Future Post Research data supplied by MfE

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Executive summary

The problem

The objective of this study was to deliver a report including peer review of scientific data supplied by MfE on behalf of Future Post and suggestions of potential tests to corroborate long term suitability claims.

Client initiatives

MfE has approached Scion to perform a scientific critique of the data supplied by Future Post in regard to scientific techniques used. MfE has inquired whether the data supplied corroborates the weathering and leaching claims. MfE has requested that Scion suggests potential tests that could strengthen the long term suitability claims relating the Future Post posts.

Key results

The material composition claimed on the Future Post website is inconsistent with the reported material composition in the supplied technical reports.

The products are claimed to be CCA free and to not leach CCA into the soil. This claim seems justifiable and reasonable.

The products are claimed to not leach. Insufficient evidence was provided to support this broad claim.

The products are claimed to be environmentally friendly. Without a comparison to alternative solutions, this claim cannot be justified.

The products have a claimed 50+ year life expectancy. Insufficient evidence is provided to support this claim.

Further work

Suggestions of tests that could be performed to corroborate the claims are made as part of this report.

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Table of contents

Executive summary	3
Introduction.....	5
Review of supplied data	6
Plastic type and composition	6
Leaching and environmental friendliness	7
UV stability and life expectancy	8
Discussion of standards and methods available.....	10
Proposed tests to validate Future Post claims	11
References	12

Introduction

MfE approached Scion to review the scientific data supplied by Future Post Ltd. in relation to performance claims for their plastic post products made from recycled materials.

The following reports were supplied by MfE:

- BioGro New Zealand Input pre-assessment application form, dated Oct 2018, assessed Nov 2018
- BioGro New Zealand Certificate of Compliance issued for Future Post, valid from 1st August 2020 until 31st July 2021
- BioGro formulation sheet, dated October 2018 (accompanying BioGro documentation)
- Callaghan Innovation report "Investigation of potential leaching into water from Future Post samples", dated November 2019
- Clariant New Zealand laboratory report, dated 2019
- Clariant New Zealand laboratory report, dated 2021.

The Future Post website was accessed for public information.

The scope of this work was to assess if the supplied reports provided sufficient evidence to corroborate the life expectancy and leaching claims made by the manufacturer.

Review of supplied data

Based on information provided on the Future Post website, their plastic post products have the following claims:

- composed of recycled plastics - type 2, 4, 5, 6, and 7.
- copper chromium arsenate (CCA) free and hence free of CCA leaching into soil
- environmentally friendly
- organic farm friendly
- do not leach
- UV stable, with 50 + year life expectancy¹.

These claims will be discussed from a scientific perspective with respect to the information provided in the supplied reports.

Plastic type and composition

According to the website 'Our Posts' page, the plastic used for the fence posts is a mixture of recycled plastics, type 2, 4, 5, 6, and 7.

The BioGro formulation that was certified stated the following composition:

- 60 % HDPE (plastic type 2)
- 38 % LDPE (plastic type 4)
- 2 % carbon black (used as a UV stabiliser and colourant)

Plastic types 5, 6, and 7 are not included in the formulation data provided to BioGro.

The Callaghan Innovation leaching report states that Future Post fence posts are made using post-consumer polyethylene. This is consistent with plastics type 2 and 4.

The Clariant report does not mention plastics type, only that they have used a customer supplied recycled material. They state that the samples tested for accelerated weathering have had stabilisers added as follows:

- No UV stabiliser (sample R-1, control)
- 3 % MLLBK-9732 (sample R + BLK)
- A total of 4 % additives (MLLBK-9732 and MLLNA-0374) (sample R + BLK + UV)

Plastic type and composition findings:

There are inconsistencies between claimed composition of the products (type 2, 4, 5, 6, and 7) and the composition reported in the scientific reports and assessments (type 2 and 4).

If the formulation of the products has changed since the provision of the BioGro certification, Callaghan Innovation leaching report, and the Clariant weathering report, the findings cannot be assumed to translate to a formulation containing different plastic types. Certification, leaching and ageing tests should be repeated using the claimed type 2, 4, 5, 6, 7 formulation.

The BioGro formulation states the inclusion of 2 % carbon black (UV stabiliser and colour) to the formulation. However, the tests supplied by Clariant present two stabilised samples, containing either 3 % additive (R + BLK) or 4-5 % additives (R + BLK + UV). Searches on what the two additives contain have been unsuccessful, and for this report it was presumed they were stabilisers as stated in the laboratory report. Discrepancies between the formulations provided in the BioGro certification and Clariant report should be remedied.

Leaching and environmental friendliness

According to the website "Our Posts" page, the products are CCA free and do not leach CCA into the soil. The products are also claimed to not leach, in a more general context. They are also claimed to be environmentally friendly, which for this report, has been assumed in the context of organics and metal ion leaching into the environment.

The post products are not made of timber, hence they do not require CCA treatment.

The BioGro certification documentation does not list CCA as an ingredient of the products. The document does not discuss leaching.

The Callaghan Innovation leaching report was commissioned by Future Post to investigate leaching in general. An in-house leaching procedure was employed, which as far as the authors are aware was not based on a known standardised procedure. Specifically, a non-quantified amount of new post material was placed in distilled water in leaching vessels. A leaching vessel with only distilled water was treated in the same manner as the samples to act as a control. The samples were leached for 21 days, and a temperature cycle was applied to the samples (6 cycles of freeze-thawing). Both organic and inorganic analysis of a leachate was performed. Organic leaching analysis was performed via gas chromatography - mass spectrometry (GC-MS), and inorganic (metal ions) analysis was performed via inductively coupled plasma - mass spectrometry (ICP-MS). Part of the water samples was removed and analysed via GC-MS and ICP-MS.

GC-MS analysis shows no compounds retained on column.

ICP-MS shows sodium contamination in the control distilled water and leaching of copper, manganese, and antimony in amounts stated to be below the safe drinking limit.

In addition, a portion (130 mL) of the total leachate solution (150 mL) was evaporated to dryness and the amount of non-volatile residue determined to assess the overall migration (total leaching) from the posts. All samples including blank have a residue level reported of 0.1 ± 0.1 g. The presence of the residue in the blank is explained as leaching from glassware.

The report states no UV radiation was applied to the samples and once UV radiation is applied in a true accelerated weathering experiment, this 'could lead to photo-degradation of the post material which could result in the liberation of microplastics or of other leachates'.

The Clariant report does not list CCA as an ingredient. This report focuses on measuring only the impact resistance of the accelerated weathering samples; leaching experiments were not part of the objectives.

Leaching and environmental friendliness findings:

CCA treatment of wooden posts is a common practise to prevent decay and increase the useful product life of the post. As the Future Post plastic post products do not contain timber, and are inherently decay resistant, CCA treatment would not be expected. This is consistent with the formulation data provided in the reports. Furthermore, as the recycled plastic used in the posts appears to be primarily of food packaging origin (sourced from Fonterra Brands and Soft Plastics Forum) and therefore compliant with food contact regulations, significant levels of copper chromium and arsenic would not be expected in the recycle². As such, the claims of CCA free seem justified and reasonable.

Leaching is the process of soluble chemicals being released from a solid material into the surrounding environment. Leaching of CCA from treated wooden posts into the soil has been reported leading to some concerns regarding their use³. The Callaghan Innovation report appears to have been commissioned in response to this concern. The report contains statements that do not provide enough scientific data to support the conclusions drawn, as outlined below:

Inorganic leachate analysis:

The concentrations reported are that in the extracted water. NZ soils are typically acidic, hence the inclusion of a slightly acidic extraction media should have been included, as this would have been

more representative of metals leaching in NZ environments. The concentration in the product itself, nor the relative amount leached per unit quantity of product, are not reported. There was no mass recorded for each part taken and the mass of the poles prior to cutting. So, although the values are very low and are, as reported, below the maximum acceptable levels, no calculations are performed to show whether the overall levels will be below the safe drinking limits, hence no conclusions can be drawn from the data as presented. Furthermore, concentrations determined in laboratory studies are not directly comparable to field situations⁴ and as such benchmarking comparisons with alternative products would provide a better indication of environmental friendliness.

Organic leachate analysis:

As stated in the report, leaching performed on new posts without exposure to weathering will give different results than the leaching performed on weathered products⁵. Even if the report states that the part of pole analysed will be in the ground, rather than exposed to sunlight, hence to UV radiation, the study was supposed to be representative of the whole post. The majority of the post will be exposed to UV radiation and no reports are provided on leaching of posts under all accelerated weathering conditions (UV, temperature, and intermittent precipitation).

The analysis of the leachate by GC-MS did not identify any organic compounds. While the limit of detection was reported to be 1 ppm, no evidence for this limit of detection through an appropriate method validation is provided. In addition, many plastic additives are known to exert detrimental environmental impacts at sub ppm levels⁶. Plastic additives and other non-intentionally added substances are highly diverse and may not be amenable to analysis by the technique of GC-MS. Other complimentary analysis techniques should be applied, such as LC-MS, to provide further confidence in the absence of organic compounds in the leachate.

The results presented for leaching are contradictory. Weights recorded are on a balance with a ± 0.1 g accuracy, and the residue weight is in all cases 0.1 ± 0.1 g. The blank has residue recorded at same level as the posts, and no calculations are performed to account for the water sample removed for analysis. As no weights of the post samples or weights of the whole post were recorded, no attempts were made to calculate the real amount of overall leachate corresponding to each post. The data cannot be considered conclusive and as such no conclusions can be made based on the data provided. The balance used in this experiment does not enable any conclusive comments to be made, as the detection limit for the sample taken is 100 ppm. For overall leaching tests, according to EU standards for plastics², the overall accepted migration limit is 60 ppm. However, the limit of detection of the method used is 100 ppm, so no conclusions can be drawn regarding the suitability of the posts based on overall amount leached.

The Clariant report presents microscopy imaging of the compounded materials. After 10,000 hours, the material containing 3 % stabiliser shows clear microfractures; at the resolution provided, the material with 4-5 % stabiliser seems to be microfracture free. The presence of microfractures corroborates the possibility of extra leaching in the material after 10,000 exposure. It is unknown how the material containing only 2 % stabiliser (the BioGro certified formulation) would behave after 10,000 hours exposure. This also raises the question of micro- and nano-plastic generation from the post products during their service life and what environmental impact this may have. Microplastics are known to be shed from plastic items during service life⁷, which is accelerated by weathering and degradation^{8,9}. Micro- and nano-plastics have been shown to elicit ecological impacts in terrestrial environments¹⁰. Given the exterior application of the post products, an assessment of micro- and nano-plastic release and ecotoxicity should be demonstrated as part of the environmentally friendly claims.

UV stability and life expectancy

According to the website, the material is UV stable and has a 50 years+ life expectancy.

The Biogro formulation sheet states that the material contains 2% carbon black, added for colour and UV stability. Carbon black is known as a UV stabiliser.

The Callaghan Innovation report does not cover UV stability or life expectancy.

The Clariant laboratory report stated that materials were stabilised with:

- 3 % MLLBK-9732
- 4 % MLLBK-9732 and 1 % MLLNA-0734 in customer sample ID (3 % and 1 % respectively in the objectives)

Samples with no stabiliser, and with 3 and 4-5 % stabiliser respectively were subjected to 10,000 hours total accelerated weathering, according to ISO 4892-3 standard. Clariant states that 1000 hours are equivalent to 217 days outdoors in NZ. Microscopy and impact strength testing results are provided.

Impact strength testing shows a significant drop in impact strength in the non-treated sample after 10,000 hours treatment. The sample stabilised with 3 % single additive has a slightly elevated impact strength value compared to pre-weathering. The sample stabilised with 4-5 % mixture of additives has similar impact strength values (within the error of the instrument), but overall had the highest impact out of the three materials.

UV stability and life expectancy findings:

It is unclear from the reports whether the stability testing that was provided is performed on the same material that has BioGro certification (types 2 and 4) or whether it is the same as the one claimed on website (types 2, 4, 5, 6, and 7). This applies to both material type and stabiliser type and amount present in the post.

The Clariant report shows (by microscopy) slight deterioration in the material compounded with 3% additive, and no visible deterioration in the material compounded with 4-5% additives.

Materials have been treated according to accelerated weathering standards for the duration of 10,000 hours. Based on their calculation, 10,000 hours would equate to 2170 days in the field, so an equivalent of 5.94 years.

Based on the results there is no scientific basis to show that the posts have a 50 years+ life expectancy. Tests have only been performed for the two formulations supplied to Clariant for a duration of just under 6 years.

Discussion of standards and methods available

It is well-documented that plastics decompose in the environment and that leaching and degradation products vary with amount of environmental exposure¹¹. Most of the tests are adapted from the construction industry tests, as the methods developed for assessment of construction materials are designed to mimic long-term environmental exposure¹². There is a lot of debate on soil bed testing to assess true leaching in the soil, but most of the accepted tests are based on water leaching. Two types of tests can be performed to mimic leaching at each stage-point of the weathering:

- Tank tests (total immersion, dynamic surface leaching), in accordance to CEN/TS 16637-2¹³; these allow for total water collection and set up rules on the amount of water that needs to be in contact with a set amount of polymer
- Intermittent immersion, in accordance with EN 16105¹⁴; these account for periods of dry and wet environmental conditions and are considered more environmentally relevant.

Both standards can be modified to adjust for various conditions of use of the materials. Measurement of the pH and conductivity is stipulated, along with other relevant tests for total organic carbon, organic substances and inorganic substances.

For both types of tests, the concentration of the leachates is transferred to a number corresponding to emissions per surface area of polymer exposed¹⁵.

Ageing of materials will influence their strength and chemical composition. As ageing is heavily influenced by UV light, temperature and moisture exposure, all tests that are developed to determine accelerated ageing will be based around different environmental exposure scenarios. The most common tests, outlining the degree of UV exposure, are outlined in standards ASTM D 7869:2017¹⁶, ASTM D 4239¹⁷, and ISO 4892:2013¹⁸. These differ mainly in the light source and intensity that the samples are subjected to. Consensus across the standards and best practice guides uses a conservative assessment of one week accelerated exposure corresponding to one month of real exposure; this was calculated based on the amount of hours of UV/light exposure that the material is subjected to during a day.

Common polymer characteristics are measured pre- and post-weathering, based on the common standards that are used for these tests. For example only:

- Impact strength is measured in accordance with ASTM D 4812¹⁹
- Tensile strength is measured in accordance with ASTM D 638-14²⁰.

Surface decomposition (physical breakdown) is usually monitored via microscopy, and chemical decomposition (breakdown products of the polymer, breakdown products of the additives) are monitored via infrared spectroscopy and analysis of the leachates (chromatography coupled with mass spectroscopy for common organic molecules, and ion coupled plasma-mass spectroscopy for metal ions).

One of the new emerging topics in environmental studies is the possibility of microplastics formation during the breakdown of a polymeric product. There are no standardised test methods, but Scion-developed microplastics analysis methods have been published²¹. Microplastics are identified from a range of environments and the number, size and chemical composition is assessed.

Proposed tests to validate Future Post claims

In light of the scientific findings from the reports submitted by Future Post, of the inconsistencies highlighted, and of the industry best practice that was outlined in the previous sections, the following tests are suggested to corroborate the Future Post claims:

Posts composed of recycled plastics - type 2, 4, 5, 6, and 7.

It is recommended that the inconsistencies between the claimed composition and composition detailed in BioGro and testing documentation are remedied.

Full characterisation of the material as currently marketed, including type of plastics, percent composition, percent UV stabilising additive, followed by re-certification by BioGro for the finalised formulation should be undertaken.

Posts are environmentally friendly

This claim can be made if there is benchmarking against alternative solutions (other available post products). A possible LCA or other whole of life comparison could strengthen the environmentally friendly claims, alongside the leaching and stability tests outlined in the next section.

Posts do not leach, are UV stable, with 50 + year life expectancy

The following set of experiments, based on international testing and standards, should be performed:

1. Full 'point zero' characterisation of the fence post: flexural and impact strength, infrared spectroscopy, and microscopy
2. Accelerated weathering of the material followed by regular testing of the material: in order to validate the life expectancy of the 50 years+ of the material. This will have to be performed for a total of 84,000 h accelerated weathering in accordance with one of the internationally accepted standards listed above

At intervals, the material subjected to accelerated weathering to be reassessed:

- a. Leaching (using tests modified from Bandow 2020) for total amount leached, in both distilled water and in a soil water simulant (the most accepted is 1 M KCl); volume of water used for leaching must be dried in a container that can be measured on a suitable balance (readability of not less than 0.0001 g), in triplicates that are going to match within acceptable CV; deionised water must be used to avoid solids being found in the blanks.
- b. Leachate analysis for organic and inorganic contaminants and breakdown products (as per NPL Good Practice Guide)
 - i. pH, conductivity, and total organic carbon
 - ii. GC-MS, LC-MS and high performance liquid chromatography with diode array detector (each able to identify different classes of organic compounds)
 - iii. ICP-MS (able to identify leaching of metals)
- c. Generation of microplastics under abrasion (using suitable standard fretting/abrasion test methods (e.g. ASTM G204-21²², ISO 9352:2012²³) and microplastic analysis based on Bridson 2020)
- d. Flexural and impact testing according to international standards listed above
- e. Infrared spectroscopy to analyse for breakdown products in the polymer
- f. Microscopy imaging for microfractures or pitting of the material, that could lead to microplastics formation

These tests can be performed just once at the end of the life expectancy of the material or on a regular basis (monthly) to assess the progress of damage in the polymeric matrix.

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