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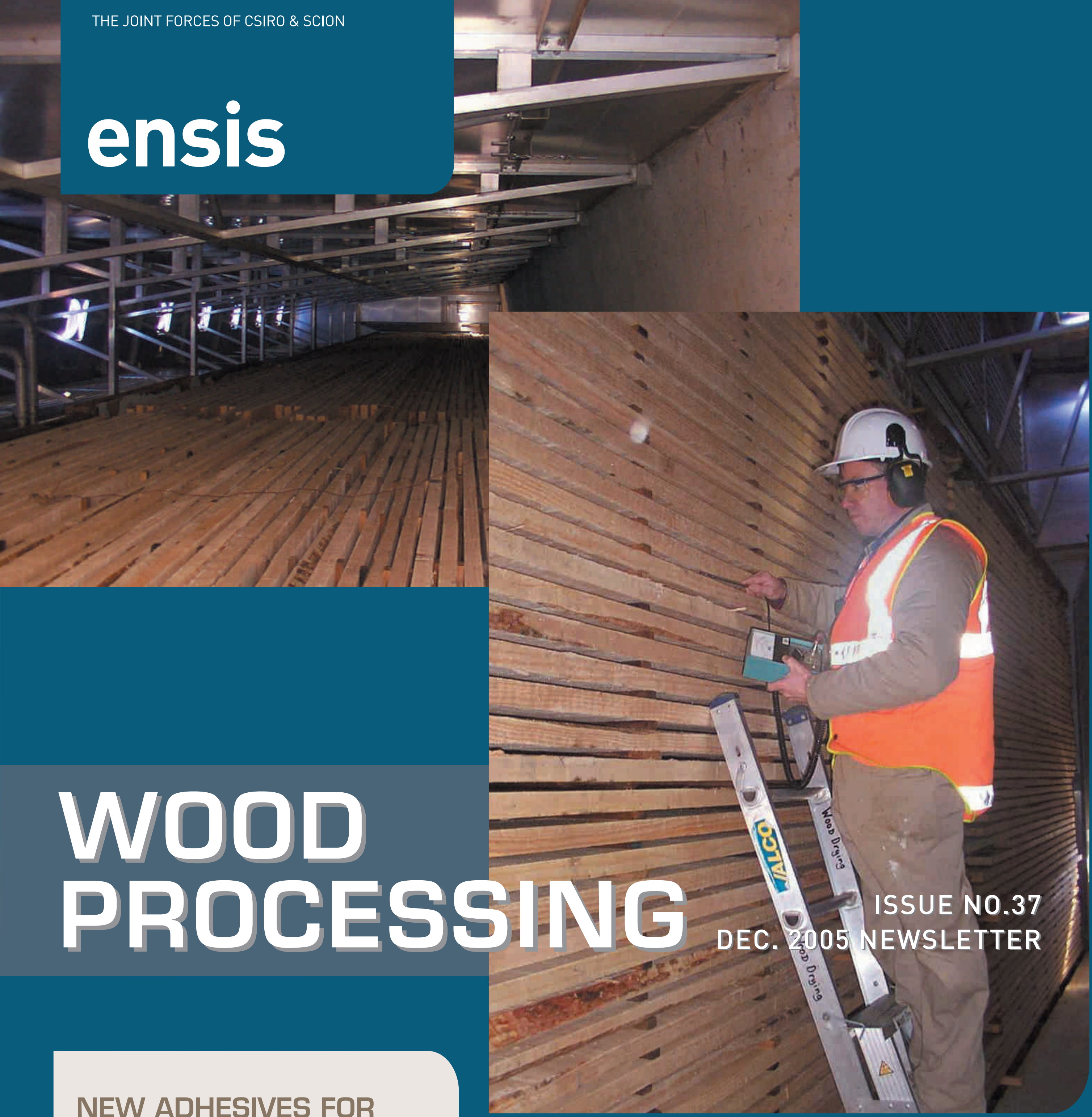

WOOD PROCESSING

ISSUE NO.37
DEC. 2005 NEWSLETTER

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CSIRO
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Sawmilling

Issue No. 37 December 2005

NEW ADHESIVES FOR ENGINEERED TIMBERS

Ken Van Langenberg

In a major 4-year research project, Ensis is collaborating with researchers at Monash University (Victoria) to assess the long-term durability, in the Australian environment, of engineered wood products (such as glulam or laminated timber) manufactured with a new generation of adhesives.

Under the current Australian Standard, manufacturers are restricted to using resorcinol formaldehyde and phenol resorcinol formaldehyde adhesives in glulam engineered wood products for external structural applications. Potentially attractive alternatives, isocyanate-based adhesives (IBAs), have recently been approved in parts of Europe. The findings of this project will help determine whether IBAs should also be allowed in Australia.

Dr Ken Van Langenberg of Ensis Wood Processing and Professor Bob Milner of the Timber Engineering Centre at Monash University head the $1.7 million project. The Forest and Wood Products R&D Corporation, Queensland Dept of State Development, Trade and Innovation, adhesive manufacturers Syntec, Ashland and Purbond, and the integrated forest products company Weyerhaeuser are providing financial support

Glulam is regaining its popularity for a wide range of structural uses, from major structural components in bridges to a variety of structural members in commercial buildings. Advantages claimed for IBAs over currently used adhesives include reduced costs (smaller quantities required), easier handling, better appearance (glue is transparent), and no formaldehyde emissions.

Key questions to be answered by the project include: how well does the new glue bond Australian timbers, and what is the long-term durability under Australian climate extremes, heat and cold, drought and high rainfall?

Laboratory research will include studies of the chemical durability of the glues, their response to changes in relative humidity, and their ability to withstand the expansion and contraction caused by changes in the moisture content of wood.

Field tests will include a comparison of IBA-bonded glulam exposed to the weather for 3 years with that of an equivalent conventional glued product. Half the samples will be under continous load, to test the combined impact of stress and exposure. On completion of exposure, samples will be laboratory-tested to destruction, and degradation in the glue line will be assessed. Findings will be applicable to laminated veneer lumber and plywood.

It is hoped that the findings will also help researchers design a rapid test for long-term durability.

PRIMED RADIATA WEATHERBOARDS: PREVENTING PROBLEMS

Bernard Dawson and John Turner

The following article relates to an investigation into why certain problems were encountered during installation of primed weatherboards (250 mm wide) that were hit by severe weather conditions.

The erection of weatherboards actually involves a number of parties, not just the builder. Architects, Owners, Manufacturers, and Retailers are included. Increased knowledge may help them all work together cohesively, in adverse conditions — and stay in the black.

Wooden claddings are a proven performer. They have been used for hundreds of years, although perhaps not made of radiata pine. But it's not as simple as many would have thought. Given an adverse set of circumstances, reputation is simply not enough to ensure that all parties prosper.

The issues involved relate to manufacture, installation, and coatings, and apply more specifically to:

- Use of wide weatherboards (up to 250 mm wide)
- Heavy rainfall encountered during installation
- Gap spacing between boards
- Weather grooves.

While the discussion here is based on radiata pine weatherboards, the principles are relevant for other wood species.

Radiata pine weatherboards typically are:

- Finger-jointed and possibly edge-laminated
- Available in a variety of profiles
- Preservative-treated to Hazard Class H3.2 (above ground, exposed to weather)
- Pre-primed
- Horizontal (although vertical profiles such as shiplap and board and batten are also used).

In older times wooden weatherboards were made from quartersawn boards, with the aim of producing the least shrinkage and swelling in width (growth rings run from face to back, i.e., the width is mainly in the radial direction of the log). These days boards tend to be produced mainly from flatsawn timber, i.e., the width is in the tangential direction. As a "rule of thumb", tangential shrinkage/swelling is twice that of radial.

Wood will expand and contract naturally with changes in the atmosphere, and in practice weatherboards should be installed with allowance for a certain amount of movement. A correctly applied top coat will minimise water uptake and thus swelling.

Consider the scenario of a period of protracted heavy rain occurring before the topcoats can be applied. Significant effects likely to be observed as a result of wetting are:

- Swelling of boards in width, closing gaps between boards (Photo1)
- Cupping of boards (Photo2)
- Splitting of boards due to pressure resulting from the cumulative width expansion across adjoining boards on the wall (Photo 3)
- Weathergroove misalignment
- Nail pull-through and nail bending (Photo 3).

Photo 1. Expansion

Photo 2. Cupping

Photo 3. Splitting

Swelling

In order for any expansion or contraction to be minimised, the moisture content of the boards at installation needs to be close to the average equilibrium moisture content (EMC), generally accepted to be around 14–18% mc for most of New Zealand. If an otherwise-straight wall is erected, with primed but not top-coated boards, bad weather can result in a significant uptake of moisture. The primer is **not applied to prevent moisture penetration** since it does not have the physical or chemical characteristics which would allow it to achieve this. The function of the primer is to act as an interface between the wood substrate and the undercoat/topcoat in order to maximise adhesion between the various layers.

The BRANZ Good Timber Cladding Practice report shows that a 6% change in moisture content for mature radiata pine corresponds to a movement of 2.6 mm for a 200-mm-wide board. For a 250-mm-wide flatsawn board, this would be a tangential increase of 3.3 mm. If this dimensional change were cumulative over a wall of, say, 15 boards, this would result in a combined movement of 50 mm.

Cupping and splitting

Cupping results from board expansion exceeding the gap that has been allowed between boards to accommodate board movement. When the cupping distortion exceeds the modulus of rupture of the board, irreversible splitting occurs.

Generally (as per the building standard) boards will be fitted with only a 2-mm expansion gap; once rain-soaked primed-only boards have swollen by more than 2 mm, cupping is inevitable. The 2-mm gap is insufficient to take up board movement when expansion exceeds 2 mm per board. The heavier and more prolonged the rain and the lower the initial moisture content, the greater the expansion. With boards wider than 200 mm, the gap needs to be increased. For 250-mm-wide boards, at least 5 mm would be appropriate. However, such advice is not offered in standards or BRANZ documents. If boards are only primed, even if they are at equilibrium moisture content (say 14 to 18 %), they will still swell substantially.

Weather grooves

With commonly manufactured profiles, increasing the gap between boards will result in misalignment of the weather grooves. BRANZ recommend a single 4 × 4-mm weather groove although maintaining the present 2 mm depth on face and back of each board, but making the groove wider (say 6 mm) should achieve the same end and allow for any seasonal movement of the board.

Nailing

On the issue of nailing, the standard (NZS 3604:1999) calls for single nailing of boards. When swelling and cupping have been severe it is possible that the nails will pull through the board or be bent by board expansion. If there has been no splitting, renailing may be all that is required to reattach boards against drying out. Double nailing is not recommended. If boards are double nailed, there is the possibility of splitting if the board shrinks. Once again, a good paint protection system will slow down the uptake or loss of moisture content, thereby reducing shrinking/splitting. The wider the boards that are double nailed, the greater the potential shrinkage if moisture content reduces, and the likelihood of splitting is greater.

Lessons learned from the investigation into weatherboards

- Wide weatherboards (greater than 200 mm wide) are outside the profile dimensions in NZS 3617 and special attention is needed to gap spacing and weather groove alignment in attaching them.
- An installation gap of 3 mm is recommended for boards 200 mm wide, and 5 mm for 250 mm wide.
- The gap spacing needs to be considered when machining the capillary groove in the profile to allow correct positioning.
- Alignment of weather grooves, while boards are in service and experiencing varying equilibrium moisture contents, may require design changes by manufacturers in order to remain functional.
- Greater attention is required to having the correct moisture content during machining, and at the time of installation, and until painting has been completed.
- Priming is not a moisture-excluding coating and all haste should be given to undercoating and topcoating
- Double nailing is not recommended for boards because of the propensity to splitting on drying out.

Relevant documents and standards for weatherboards

The New Zealand Building Code, Building Industry Authority, 1992

NZS 3602 – 2003	Timber and wood-based products for use in buildings
NZS 3604 – 1999	Timber framed buildings
NZS 3617 – 1979	Specification for profiles of weatherboard, fascia boards and flooring
NZS 3640 – 2003	Chemical preservation of round and sawn timber
AS/NZS 4284 – 1995	Testing of building facades

The BRANZ publication “Good Timber Cladding Practice” (1997) is also often referred to by various parties.

Wood Quality

Issue No. 37 December 2005

DOES JUVENILE WOOD NEED REDEFINING?

Dave Cown

The term “juvenile wood” has been widely used in reports on wood products as a convenient method of describing wood from close to the pith. There are strong patterns of development of wood properties with tree age in many species, predominantly pines and spruces which are very widely used in international commerce. Because wood density has long been considered the most important wood property, affecting all major end uses, the density pattern formed the basis of the early juvenile wood definitions. The transition to mature wood was considered to coincide with levelling off of the steep density increase with ring number from the pith. Thus, in radiata pine the juvenile wood was commonly defined as within 10 rings from the pith. Products containing juvenile wood were consistently weaker and less stable.

In recent years, manufacturers of wood products have developed more sophisticated tools for segregating material on the basis of “fitness for market”, e.g., methods for determining the wood properties influencing product performance — particularly stability. A key property, underrated in the past, is microfibril angle (MFA) — the angle of the cellulose chains within the wood cell walls compared to the cell axis. This property is closely linked to both intrinsic stiffness and longitudinal shrinkage — a major component of stability.

SilviScan is a new research tool which can accurately measure MFA, and has been widely used to document the within-tree patterns. An important discovery has been that, while there is radial variation of MFA with increasing age, the pattern is not constant at all heights in the stem, unlike the situation with wood density. In radiata pine the MFA values are higher (less desirable) and the gradients much steeper in the lower part of the tree (up to 3 m height). Detailed studies have shown that this region also yields the material with the lowest stiffnesses and the greatest shrinkages. So the “juvenile wood” can have consistently low wood density but variable MFA, depending on tree height. Similarly, studies have also confirmed that juvenile wood has high spiral grain, but that actual values tend to increase upwards in the stem.

Thus, while the term “juvenile wood” conveys a concept, it does not fully describe wood properties. For solid wood products it generally has a negative connotation. However, it is quite possible that the levels of individual properties within the juvenile wood zone in wood from a particular tree can be found in the mature wood of another.

Some scientists have suggested that the term juvenile wood needs redefining to reflect more accurately the patterns of individual properties, and this could certainly be useful in research investigations. However, for applying the more recent findings of MFA variability to industry the easily applied “number of rings from the pith” definition for juvenile wood is still the most practical and includes much of the troublesome wood.

ACOUSTIC ASSESSMENT OF STANDING TREES FOR PRODUCT PERFORMANCE

John Lee

Non-destructive testing of standing trees has been a major focus for the last few years as we try to gain early insight into the performance of lumber cut at a later date. In particular, stiffness assessment is becoming of great importance to the forestry sector. So many organisations have been attempting to make or adapt tools that can help make reliable and accurate assessments of forest trees.

Stiffness prediction

Timber stiffness is an important property for structural applications as it is related to a number of wood properties including microfibril angle, grain angle, and wood density. "Time of flight" acoustic tools have been developed to the stage that they can now provide a non-destructive and reliable indication of timber stiffness without the costly assessment of cores for microfibril angle using systems such as SilviScan. Acoustic methods are becoming widely used in many different applications from breeding to resource evaluation to product testing.

The IML Hammer (Figures 1 and 2) adapted by Ensis can be used to measure velocity in standing trees, thus providing a reliable prediction of stiffness.

Tools have been validated with many studies that have gone from tree to product (Wood Quality Initiative).

Selection of seed source trees

Acoustic methods can be utilised for quickly screening stands for "plus-trees" that can be further investigated and placed in breeding programmes. This process has been developed for the New Zealand Douglas Fir Cooperative.

Figure 1. Assessing a tree with the IML Hammer

Figure 2. The IML hammer with the probes developed by Ensis.

NEW INSIGHTS INTO COMPRESSION WOOD FORMATION

Ralf Möller and Adya Singh

Trees respond to environmental factors in various ways. For instance, the annual growth rate of trees is influenced by climatic factors such as precipitation and temperature, and the width of tree rings mirrors these climatic conditions. In addition, the wood structure of trees may be altered and the walls of individual cells modified in response to wounding and to other mechanical and physical stresses. An example of this is the formation of compression wood in softwoods in response to leaning or bending of the stem. The wood formed is different from normal wood in its composition and properties. Characteristic features of severe compression wood are rounding of tracheids, presence of intercellular spaces, thicker cell walls, helical cavities in the secondary wall, and higher lignin concentration in the outer region of the S2 layer. Higher lignin content and the presence of (1→4)-β-D-galactan in cell walls are generally regarded to be the two most characteristic compositional features of all grades of compression wood. It appears that lignin and galactan may be chemically linked, because most of the galactan is removed during delignification. However, so far there is no direct evidence for the co-localisation of galactan and lignin within the cell wall. We used immuno-histochemical techniques to localise galactan in the cell walls of compression wood of *Pinus radiata* seedlings. We labelled the galactan with an anti-(1→4)-β-D-galactan monoclonal antibody and used confocal fluorescence microscopy to examine the pattern of galactan distribution in compression wood cell walls.

We used a low magnification to compare a large area of normal and compression wood for lignin concentration of cell walls, based on lignin autofluorescence of their cell walls (Figure 1). The brightness intensity reflects the concentration of lignin, with greater brightness indicating higher lignin concentration in cell walls. Greater brightness is associated with the region of secondary xylem containing compression wood cells; in contrast, the region containing normal wood cells displays a much reduced brightness. As shown in Figure 2, the pattern of immuno-localisation of galactan closely corresponds to the pattern of autofluorescence in the secondary xylem, with the compression wood region being brightly fluorescent for galactan. The cell walls in the normal wood region show only a slight fluorescence. Interestingly, a narrow band of strongly fluorescing xylem for galactan (Figure 2) shows only marginally greater autofluorescence than the normal xylem present on either side of this band (Figure 1). As for other xylem tissues, rays which show strong autofluorescence in localised places lack fluorescence

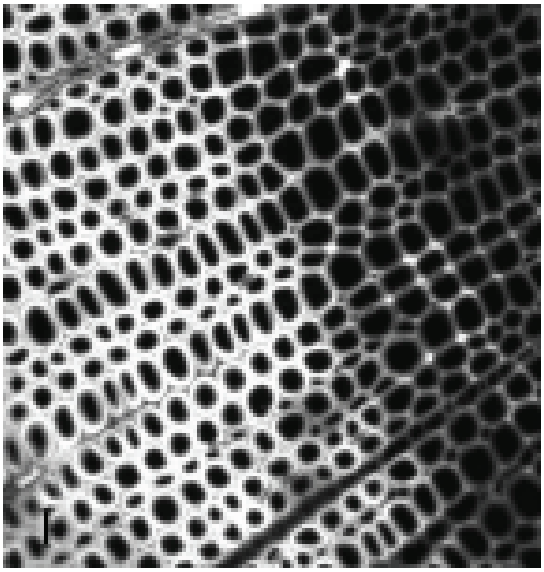

Figure 1. Confocal fluorescence micrograph of a transverse stem section of a 1-year-old *Pinus radiata* seedling, showing lignin autofluorescence.

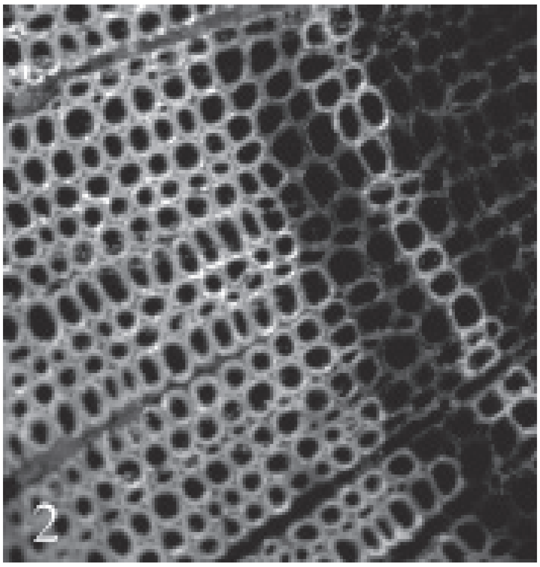

Figure 2. Confocal fluorescence micrograph of the section shown in Figure 1. Immuno-fluorescence localisation of (1→4)-β-D-galactan.

for galactan. Phenolic extractives present in ray parenchyma cells are likely contributors to the autofluorescence observed in these tissues. The patterns of cell wall autofluorescence and galactan immuno-fluorescence are more clearly resolved in the images shown in Figures 3 and 4. In compression wood tracheids the region of the cell wall which shows strong autofluorescence, forming a continuous band along the compound middle lamella, corresponds to an outer region of the S2 layer where lignin concentration is greatest (Figure 3). This region of the S2 layer shows strong fluorescence from immuno-labelled galactan (Figure 4), the brightness intensity being greatest in cell wall regions where lignin also occurs in highest concentrations in a range of compression wood. The compound middle lamella regions in compression wood are not labelled with the anti-galactan antibody. Rather specific localisation of galactan in the outer S2 cell wall region, which becomes most highly lignified, suggests that galactan may be involved in modelling of cell wall architecture in this region in a way that facilitates lignin deposition. The present work demonstrates that the bulk of galactan is associated with the outer layers of the secondary wall and that the galactan antibody is a good marker for the identification of compression wood cells. The work presented also demonstrates the value of confocal immuno-fluorescence microscopy in understanding processes related to compression wood formation in trees.

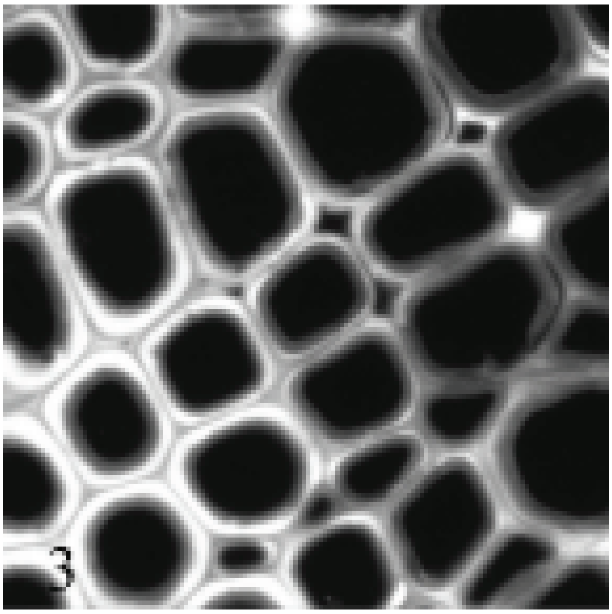

Figure 3. Confocal fluorescent micrograph of a selected area from the section shown in Figure 1, showing lignin autofluorescence.

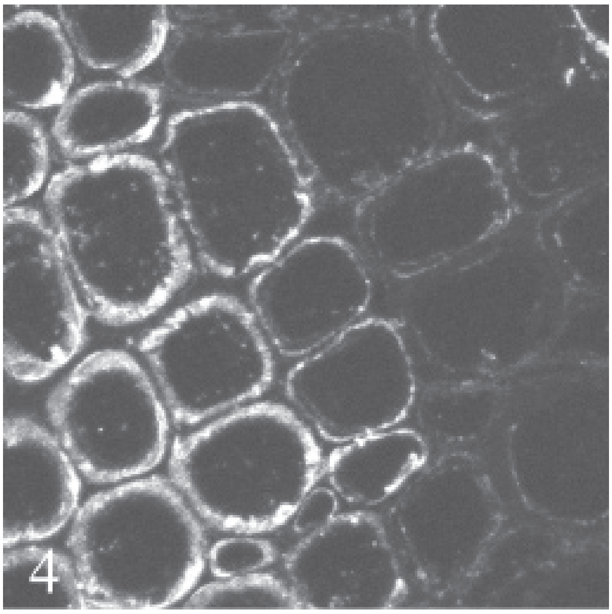

Figure 4. Confocal fluorescent micrograph of the section shown in Figure 3. Immuno-fluorescence localisation of (1→4)-β-D-galactan. Compression wood cells are most intensely labelled in the outer S2 cell wall region. The compound middle lamella is not labelled.

AWARD OF SHORLAND MEDAL

Dr Adya Singh has been awarded the prestigious Shorland Medal by the New Zealand Association of Scientists. The Shorland Medal is one of the top awards for science in New Zealand, offered for the significance and originality of a personal, lifetime contribution to basic or applied research. It was presented at the Royal Society of New Zealand's 2005 Science Honours Dinner on 16 November 2005.

Adya's citation refers to his "outstanding contribution to basic and applied plant and wood sciences". We all offer him our warmest congratulations and best wishes.

Wood Drying

Issue No. 36 July 2005

STEVE RILEY ANSWERS FAQs

How can I be sure cold kiln airflow measurements apply to a hot kiln? I see the current drawn by the motors decreases, so the air flow must be lower!

We are often asked the question "If I measure my kiln airflow when its is at ambient temperature, what is the airflow when the kiln has reached setting?"
The answer is fairly simple:

The airflow is the same.

Since this is routinely not believed (until we offer to hire — at the expense of the doubter — an asbestos suit and supervise the infidel in entering the kiln to find out), we thought it timely to "prove" it: Thus

- To force air around a closed circuit, a pressure difference is needed. The higher the pressure developed, the more flow. The static pressure required for a fluid of density ρ in a kiln can be expressed as

$$\Delta P = \Delta P_{stack} + \Delta P_{heatcoil} + \Delta P_{fan\text{-}orifice} + \Delta P_{1stbend} + etc$$

$$\Delta P = \left[\frac{\rho R v^2}{2}\right]_{stack} + \left[\frac{\rho R v^2}{2}\right]_{heatcoil} + \left[\frac{\rho R v^2}{2}\right]_{fan\text{-}orifice} + \left[\frac{\rho R v^2}{2}\right]_{1stbend} + etc.$$

  When expressed in terms of volume flow (where velocity is corrected for the flow area in each part of the flow path) a simple rising curve can be plotted. This is the kiln curve in Figure 1. Since density decreases as the kiln heats up, the hot kiln curve sits below the cold kiln curve.

- To develop this pressure a fan is needed and it has a pressure volume flow characteristic curve that depends on its pitch, diameter, rpm, and density. These curves are supplied by the manufacturer and for a given pitch, diameter, and rpm would look like the fan curves in Figure 2. Again, as density decreases as the kiln heats up, the hot curve sits below the cold curve. These curves make sense in that a fan working into a high pressure drop (high resistance) system will deliver low volume and vice versa — one working into a low pressure drop (low resistance) system will deliver a high volume.

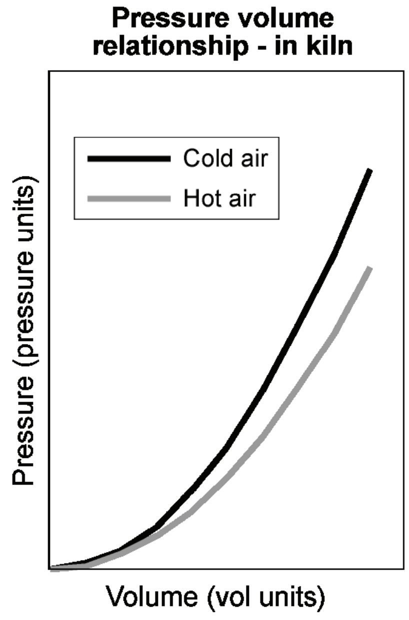

Figure 1. Kiln PV Curve

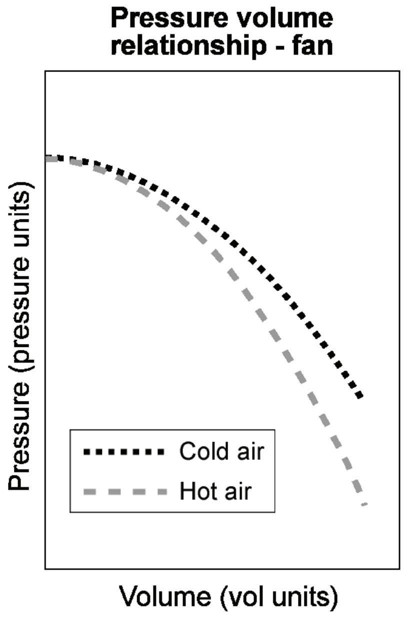

Figure 2. Fan PV curve

- The actual volume delivered is thus where the fan and the kiln curve intersect, shown in Figure 3. Here it can be seen that the volume of air delivered is constant. Note that the pressure developed/required reduces with the hot kiln. This explains why the motor current decreases when the kiln heats. Power required to move air flow is

$$Power(kW) = \frac{PV}{efficiency}$$

Since P has reduced with air density, the power and thus the motor current is reduced also.

Thus we have explained why —

Airflow delivered in a kiln is the same if measured hot or cold. Thus, you can trust the cold measurements made during kiln commissioning.

The fan power requirements reduce with rising temperature (falling air density).

Variable Speed Drives (VSDs) can be economic on kilns. The kiln motor size depends on the worst case, which is in fact when the kiln is cold. If you slow the fans down while the air temperature is low (i.e., while air density is high) you can, in some instances, afford to fit smaller motors to your kiln.

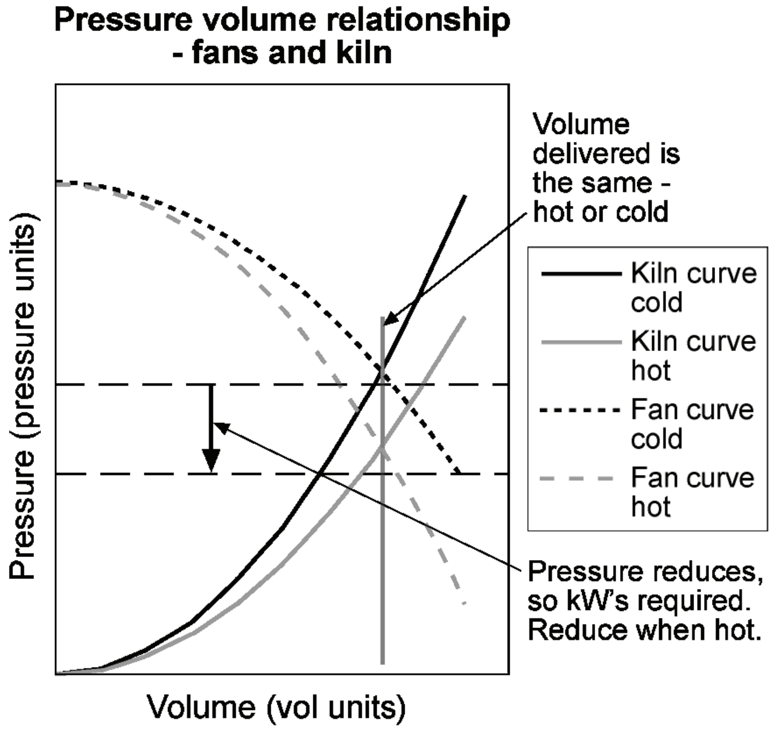

Figure 3.

ENSIS / INDUSTRY MULTICLIENT DRYING RESEARCH PROJECTS: 2005/2007

Membership of the Ensis/Industry Multiclient Drying Research Group (MDG) is currently open. This successful wood drying research group which has been run by Forest Research since 1988, is now run by **Ensis** (an unincorporated joint venture of CSIRO and Scion). The structure of the group has undergone significant change this year, and it is hoped that the changes will allow us to be more responsive to your company's needs. We hope to jointly progress the art of wood drying by continuing to do focused practical projects, as well as expand into a more holistic approach and examine more strategic issues.

This year the research group is including a joint research programme with Wood Quality Initiative Ltd (WQI) to assess the impact of wood property variation on drying quality. This means the MDG will change to a 2-year cycle. The fee structure of the group has also been reviewed, resulting in a slight membership fee reduction for most companies.

The benefits to a company from participating in the Multiclient project include:

- Participation in a large research project at a minimum individual cost.
- Attendance at Project meetings, which provide an opportunity for discussion with Ensis and other progressive companies.
- Access to agreed areas and results from some Wood Quality Initiative Ltd programmes, plus participation in a jointly funded project.
- Opportunities to improve drying quality.
- Access to new drying technology, which is not available to non-participants.
- Day-to-day advice on drying problems, provided by Ensis.
- Access to the MDG members-only web page containing drying information and previous reports.

- Technical links with Australian, Chilean, and North American companies involved in HT and accelerated conventional temperature drying.
- Membership can be used as a marketing tool to demonstrate willingness to confront technical issues.

The cost of participation in the group has been reviewed and is now more attractive for members with small to medium numbers of kilns. It is now $NZ1250 per kiln chamber, plus a $NZ750 membership fee. The cost of participation is capped at a maximum of 20 kilns. A kiln chamber is equivalent to HT or ACT kiln ≥ 60 m^3. For members without kilns, such as kiln and energy suppliers, there is a membership fee of $NZ5000.

The most recently completed research project included investigations into improved steaming techniques and measurement during steaming aimed at improving uniformity and reducing overall process time. Another study of storage of HT and ACT dried timber, showed how moisture content and stress changed during storage. Members received a moisture content response calculator. The small research topic investigated recovery from drying interruptions.

The last project had 21 industry participants including several of the Australian, Chilean, and North American corporates. The research, which remains confidential to participants for at least 2 years, provided practical recommendations on how to improve industrial practices and improve profitability.

If your company would like to be part of the Ensis/Industry Multiclient Drying Research Group, contact Steve Riley or Ian Simpson at Ensis.

The research topics for the current Multiclient Drying Research Group 2005–2007 are:

Drying a variable resource, a joint MDG/WQI project

Objective: Assess the impact of resource variability on drying quality. This project will have a 2-year programme, and will be funded jointly by members of the MDG and WQI.

Benefits: This project brings together new software for distortion prediction, innovative methods to study drying and wetting behaviours for a range of material types, and research into the fundamental links betwen adsorption behaviour and stress relief.

Topics include:

- Simulate drying/sawing strategies: Compare [Dry→Rip *vs*. Rip→Dry]
- Evaluate the influence of variation in wood structure and properties on wood-moisture interactions
- Examine the role of variable material properties in stress relief.

Complete summary of MDG topics and issues

Objective: Provide an easy guide to what was done on every research topic during the life of the MDG

Benefits: Will allow members to use the vast store of information embedded in the MDG.

Drying schedule optimiser

Objective: (i) A strategic tool for schedule selection that minimises $\$/m^3$

(ii) The basis of an adaptive algorithm to optimise DB/WB/airflow combinations within a schedule

Benefits: Will allow operators to be aware of actual costs and have tools to minimise $\$/m^3$

Kiln brown stain

Objective: Gain more knowledge on the occurrence of kiln brown stain and benchmark a new assessment technique

Benefits: Additional information to help manage the costly problem of kiln brown stain.

Environmental

Issue No. 37 December 2005

AN APPROACH FOR COMPARING THE ENVIRONMENTAL PERFORMANCE OF DIFFERENT DECKING PRODUCTS

Barbara Nebel, Johannes J. Pedersen, Per S. Nielsen

The success of biomaterials depends strongly on the public perception of them, and this is influenced by environmental and social factors. Life cycle assessment can help to compare the environmental factors of different products. Environmental implications are closely linked to the susceptibility of biomaterials-based products to degradation and deterioration, and therefore the need to use technologies to increase the longevity of such products. Over time a range of treatments has been developed to make timber more durable, but almost all types of treatment have an impact on the environment through the use of chemicals or energy. In order to assess these environmental issues the whole life cycle has to be taken into account, including the use phase and disposal. One form of treatment might use more energy or chemicals, but the product might last much longer and not need to be replaced as often as another one. Other products might have their main impacts during the disposal phase.

The aim of this project was to compare the whole life cycle of three types of decking products — CCA-treated pine, acytelated pine, and thermally treated pine. The results of this comparison can then be used for social research into the acceptance of modification of timber.

The life cycle of the decking products was divided into the following steps:

- Forestry
- Sawmilling
- Treatment of timber
- Use of deck
- Disposal of deck
- Transports between these stages

An example of system boundaries is shown in Figure 1. The production of the diesel and energy required was included, but is not shown here for reasons of simplicity.

The comparison is based on 1 m^2 decking, installed and used for 50 years. This is the functional unit of the LCA study. Since the durability of the three options varies, different amounts of timber were used for each system (*see* the reference flow in Table 1).

Table 1. Functional unit and reference flow for decking products

	Lifespan (years)	Build deck (times)	Reference flow (kg)
CCA-treated wood	25	2	21
Acetylated wood	30	2	21

The actual life times of the products might be different to the baseline assumptions, which are hypothetical and based on expert opinions. A sensitivity analysis on variations of the lifetimes has been calculated in the project.

Data collection is the most difficult part of the study, since all life cycle stages as well as all products used in the life cycle need to be covered, e.g., the chemicals for the production of CCA. Inventory data for the forestry and sawmilling stages are New Zealand data based on research done previously at Scion. Data for CCA treatment have been collected from expert knowledge, from published reports, and from the industry.

Acetylation and thermal treatment of timber are not done commercially in New Zealand at this stage and data on these aspects have therefore been calculated based on expert information.

In the impact assessment stage of an LCA, all raw materials and emissions are grouped and their impact on environmental issues is calculated. At first each emission is linked to one or more types of environmental impact categories which include, for example, climate change, ozone depletion, eutrophication, and human toxicity. In the next step all emissions that have, for example, an impact on climate change are converted into carbon dioxide equivalents (kg CO_2). CO_2 has the weighting of 1 whereas the more potent greenhouse gas methane has a value of 23 kg CO_2 equivalents, in other words 1 kg methane contributes 23 times as much to global warming as 1 kg CO_2. This way it is possible to add up the results of all emissions which contribute to the same environmental impact category. The other impact categories are calculated in a similar way using appropriate reference emissions.

Impact categories considered in this study are as follows.

Abiotic resource depletion

Abiotic resources are regarded as non-living, e.g., iron ore, wind energy, coal, oil. Most abiotic resources are non-renewable resources (except for wind). Renewable resources such as wood are part of the product system, i.e., their sustainable production is included in the life cycle. That means renewable resources do not get depleted.

Contributions to this category come mainly from the energy used during the life cycle of the three decking products. The use of copper, chrome, and arsenic would also be included in this category. However, some of the copper comes from recycling. Sources for arsenic are recycling, and the by-products of gold mining.

Global warming

Increasing amounts of greenhouse gases, like carbon dioxide or methane, enhance the natural greenhouse effect and lead to an increase in global temperature. During the 20th century, the global average temperature increased by about 0.6°C due to the enhanced greenhouse effect.

Carbon sequestration in the forest plays a major role in the analysis of the decking products. Taking the full life cycle of the products into account means that the landfill is also included. Since only a small fraction of the timber actually decays there, the system functions as a carbon sink. Thermally treated timber, which has to be replaced several times during the use phase of 50 years, and uses therefore the greatest amount of timber, consequently provides the largest carbon sink. However, emissions from transport and energy use during the life cycle contribute to global warming and are therefore balanced against the carbon sink.

Ozone depletion

The ozone layer absorbs 95–99% of the sun’s harmful ultraviolet radiation and is therefore crucial for any life on earth. The natural Antarctic “ozone hole” has been enlarging since the early 1980s.

The main contributions to ozone depletion come from the production and burning of diesel in several stages of the life cycles.

Acidification

This refers to acid deposition from the atmosphere, mainly in the form of rain. Human activities can result in strong and damaging acids. Sulphuric and nitric acids are formed from sulphur oxides and nitrogen oxides that are released mainly from the combustion of fossil fuels.

Sulphur oxides don’t play a major role in the systems analysed in this study; nitrogen oxides from burning fossil fuels are the main contributors.

Eutrophication

This refers to an increase in biomass production due to addition of nutrients (mainly nitrogen and phosphorus) to soil or water. It leads to reduction in species diversity, often accompanied by massive growth of dominant species.

The production of the three decking types does not emit a substantial amount of phosphorus; the contributions to eutrophication are nitrogen-based, mainly nitrogen oxides. Since these are the most important emissions for acidification as well, the results for these impact categories are very similar.

Photochemical oxidant formation

Describes the formation of reactive chemical compounds from certain air pollutants by the action of sunlight. Ozone, a form of oxygen, is the most important chemical in this group. In contrast to the protecting role of the ozone layer in the stratosphere, ozone in the troposphere is toxic.

VOC emissions from kiln drying play an important role in the production of photochemical oxidants. Emissions from burning fossil fuels in the forestry and transport stages contribute to the formation of ozone as well. Since the sources for these emissions are similar in all three types of deckings, the level is determined mainly by the number of times each product has to be replaced, e.g., thermally treated timber has the greatest impact.

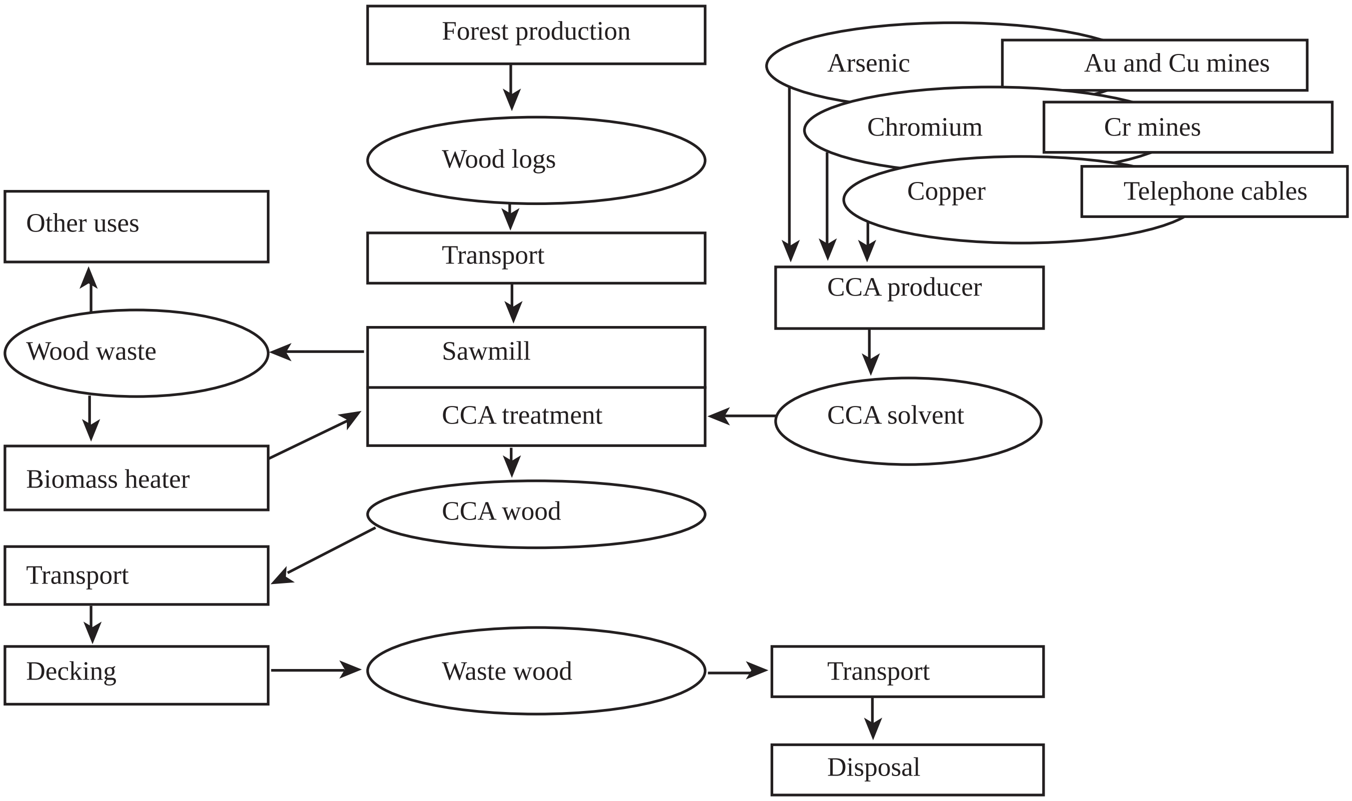

Figure 1. Life cycle of CCA treated decking products and system boundaries for the life cycle assessment

Human toxicity and ecotoxicity

Substances considered to be toxic to humans are assessed in this category. It includes substances that have both chronic (i.e., longer-term, slower acting) and acute (i.e., shorter-term, faster acting) effects. Ecotoxicity (terrestrial, freshwater, marine) is concerned with impacts on all species in terrestrial, freshwater, and marine ecosystems. Different emissions are most relevant in these three categories. Ecotoxicity is therefore split into terrestrial, freshwater aquatic, and marine aquatic ecotoxicity potential.

The chemical treatment of timber is the main contributor to impacts on toxicity. Thermally treated timber and acetylated timber have therefore very low results in these categories. For CCA treatment the use phase with its potential leaching of CCA has the greatest impact next to the landfill. However, since the landfill acts as a sink for the timber, which only decays to a small extent, the landfill functions as sink for CCA as well. More research on the leachate from CCA-treated timber in landfills needs to be done to include this. Another result of chemical treatment is that the disposal options are restricted, since regulations prohibit the burning of CCA-treated timber because of the toxic emissions.

The choice of system boundaries and the definition of the functional unit are crucial in the comparison of different products. If the comparison was based on 1 m^2 of decking, without a time frame, the results for the three products would be very different. The necessary multiple production for shorter-lasting products is quite important for a fair comparison.

The system boundaries are also important; for example, the production of the chemicals required for the treatment, or the production of diesel and energy, need to be taken into account.

Looking at the whole life cycle includes not only the forestry stage, where for example CO_2 is taken up, but also the landfill where the products are disposed of. Methodologically this has major implications for the long-term storage of CO_2, and also for the disposal of CCA-treated timber.

Wood Preservation

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ARE CHILDREN AT RISK OF POISONING PLAYING ON CCA-TREATED PLAYGROUND EQUIPMENT IN KINDERGARTENS ?

Laurie Cookson

Recently the Australian Pesticide and Veterinarian medicines Authority (APVMA) confirmed that it would restrict the use of CCA for the treatment of playground equipment after March 2006. This sparked the appearance in the media of stories that soil around CCA-treated playground equipment in kindergartens at Healesville (a semi-rural suburb of Melbourne) grossly exceeded the safe limits for arsenic. Kinderlink Inc., the parent/teacher organisation responsible for the kindergartens, sought independent verification of the claims from Ensis.

The study investigated three kindergartens. Soil samples were collected during May 2005 at distances of 100, 250, and 1000 mm from CCA-treated *Pinus radiata* posts and playground structures and, wherever possible, under them as well. For each sample, a surface area about 100 mm in diameter was loosened with a small spade, so that soil collections were actually 50–150, 200–300, and 950–1050 mm from the treated structures.

Most of the soil around playground equipment was covered with a layer of wood chip, and where this layer was less than 100 mm deep it was pushed aside so that most of the collected sample was soil. In some areas, the wood chip layer was deeper and the soil was probably inaccessible to children. Therefore, the large particles of wood chip were pushed aside to a depth of about 100 mm, to where there was a higher concentration of smaller wood chip particles and perhaps some soil. This soil/wood chip fines material was collected for analysis. Control samples were taken at least 3 m away from CCA-treated pine structures, and some were collected from outside the kindergartens.

The collected samples were sieved to pass a 3-mm-mesh screen, and acid-digested to extract any arsenic; the extract was analysed by Inductively Coupled Plasma Atomic Spectrometry (ICP-AES). The moisture content of samples was also determined. The detection limit for arsenic was 5 mg/kg.

The background or control levels of arsenic in topsoil samples from Healesville contained up to 9.1 mg arsenic/kg of oven-dried soil. Further, a control sample taken from clay and mudstone fines at the

Table 1. Mean and range of arsenic contents (mg/kg), dry weight basis, in soils and soil/wood chip fines. Mean of four replicates.

Location	Distance from CCA-treated pine structures			Controls
	50–150 mm	200–300 mm	950–1050 mm	
Haig St kindergarten	11.0	<11.0	<5.6	<6.3
	5.6–19.4	<5.0–23.9	<5.0–6.5	<5.0–7.4
Badger Creek kindergarten	<13.3	<6.2	<7.0	<5.3
	<5.0–19.4	<5.0–<6.7	<5.0–8.6	<5.0–<5.4
Queens Park kindergarten	<9.2	<7.1	<6.9	<6.0
	<5.0–19.0	<5.0–10.5	<5.0–8.2	<5.0–7.2
Don Rd sporting complex	NA	NA	NA	<6.3
				<5.0–9.1
All Healesville results	<11.2	<8.1	<6.5	<5.9
	<5.0–19.4	<5.0–23.9	<5.0–8.6	<5.0–9.1
Clay subsoil	NA	NA	NA	28.7*

< indicates that some replicates were below detectable limits.
NA = not applicable.
* one replicate.

base of an excavation into a hillside (subsoil) had the highest arsenic content at 28.7 mg/kg. These values fall within the natural range for arsenic in Australian soils, of 1–50 mg/kg, with an average of 5–6 mg/kg.

The highest arsenic content in soil collected 50–150 mm from CCA-treated structures was 19.4 mg/kg. The highest reading 200–300 mm from treated structures was 23.9 mg/kg, and 950–1050 mm from treated structures was 8.6 mg/kg. Therefore, arsenic levels were generally higher close to treated structures, but still fell within the natural levels found in soil. These values were also below the average of 30 mg/kg assumed for soil around playground equipment by the APVMA in its calculations of health risk.

The safe or tolerable intake level for arsenic in humans is 2.0 µg/kg of body weight/day. The APVMA calculated that the natural daily intake of arsenic is 0.50 µg/kg bw/d, and that the average increase for children playing on CCA-treated playgrounds could be 0.12 µg/kg bw/d, giving a total of 0.62 µg/kg bw/d. This figure indicates that for the average playground there should be no appreciable increased health risk for children playing on these structures. However, CCA will be restricted for new playgrounds because of the possibility of variability, where extreme arsenic losses might occur. The soil arsenic value used by the APMVA to obtain the total intake figure of 0.62 µg/kg bw/d was 30 mg/kg arsenic for soil around CCA-treated playground equipment. As all soil readings from the Healesville kindergartens were below this value, potential arsenic ingestion should be below the average value calculated by the APVMA, and therefore well within tolerable limits.

The results suggest that there is no need for the playground equipment at Healesville to be modified or removed based on risks to health. If felt necessary, additional precautions would be to ensure that the wood chip layer covering soil around playgrounds is replenished periodically, thereby reducing contact with soil. Also, CCA-treated pine surfaces, especially those surfaces that children grip most, could be painted with a coloured exterior paint.

The full report on this research can be found at http://www.ffp.csiro.au/Downloads/EnsisTechnicalReportNo151.pdf.

I would like to thank Kinderlink Incorporated for contributing funding to this research.

An updated information sheet on the safety of timber treated with CCA preservative can be found at http://www.ffp.csiro.au/TI-CCAFactSheet.asp

Figure 1. Queens Park, unpainted decking to slide, installed in 1998.

Figure 2. Queens Park, tunnel with decking floor installed in 1998.

Figure 3. Control sample, taken from raised rose garden bed.

WOOD PROCESSING CONTACTS

AREA OF EXPERTISE	NAME
Sawmilling	John Roper (NZ) Russell Washusen (Aus)
Log Quality / Grade Recovery	John Roper (NZ) Russell Washusen (Aus)
Timber Grading / Timber Utilisation	John Turner / Doug Gaunt (NZ) Russell Washusen (Aus)
Remanufacturing	Jeremy Warnes / John Turner (NZ)
Wood Quality	Dave Cown (NZ) Jugo Ilic (Aust)
Alternative Species (to radiata)	John Roper / Russell McKinley (NZ) Russell Washusen (Aus)
Timber Drying	Steve Riley (NZ) Richard Northway (Aus)
Timber Engineering	Doug Gaunt (NZ) Richard Northway (Aus)
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