FOLIA FORESTALIA POLONICA
Seria B, zeszyt 25, 1994

COMPARISON OF THE AGAR-BLOCK AND SOIL-BLOCK METHODS USED FOR EVALUATION OF FUNGITOXIC VALUE OF WOOD PRESERVATIVES*

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The modified agar-block and soil-block methods were used for comparing the fungitoxic value of QAC and CCA type preservatives against *Coniophora puteana* and *Coniophora olivacea*. The mass loss and moisture contents of wood were analysed.

INTRODUCTION

Since the introduction of the two basic methods for evaluating the fungitoxic value of wood preservatives: the agar-block method [16] and the soil-block method [15] as well as their first standardization [3,8], many results have been obtained using these methods to evaluate both suggested and commercial preservatives. There was, from the very beginning, a need to compare the values received from one method with those obtained with the other. A few comparative investigations have shown that on the whole, different results can be obtained for the same preservative using the two methods. This makes scientific and commercial exchange difficult, particularly when the world economy seeks greater integration.

Such a situation makes it important to find correlations between both methods that will work in general, or at least for a particular type of wood preservative. Finding the corresponding coefficients of this correlation will undoubtedly contribute to a better interpretation of results.

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* Paper presented on IRG on Wood Preservation 25-th Annual Meeting in Bali, Indonesia 1994.

STATE-OF-THE-ART

A minor comparison of the agar-block and soil-block methods was made by Leutritz [14]. He obtained considerably greater mass loss in untreated *Pinus echinacea*, using soil as the base rather than agar. However, the first major comparison of both methods used five wood preservatives, including PCP [10, 20]. The toxic value was determined semi-quantitatively, by using mass loss classes. In spite of some differences between the results from both soil and agar, the two methods were recognised by the authors as being similar. The later investigations by Varner and Krause [24] with the American agar-block method according to Hubert [13], and the soil-block of Leutritz [15], were more difficult to interpret. The toxic values obtained with *Gloeophyllum trabeum* and *Hormiscium gelatinosum* were evaluated only visually, and did not clearly indicate the differences.

Duncan [9] carried out a broader comparison of both methods using nine different oil wood preservatives and five test fungi. She found that the soil-block method was superior to the agar-block method, since the soil base offered greater moisture and humidity to the fungus over the test period. Rennerfelt [19] obtained toxic limits for creosote, and for two mixtures of salt preservative, using both techniques. He found that for water-borne preservatives the methods were practically identical, while distinctly higher toxic limits were obtained for creosote by the soil-block method. The fungitoxic value of three oil preparations in relation to various strains of *Lentinus lepideus* was investigated by Schulz [21]. He obtained over three times more mass loss in wood using the soil-block method than with the DIN agar method. With the soil-block technique, Wälchli [25] obtained many times higher mass loss for UA salt, and somewhat higher mass loss for PCP, than with the agar-block method.

The standard DIN and ASTM methods were compared by Theden [23] for sodium fluoride and boric acid using up to eight different fungi. In all cases the fungitoxic values obtained with the soil-block method were higher than for the agar-block method. Smith [22] also found that the agar-block method generally gave lower toxic values than the soil-block method. On the basis of a number of investigations, Becker [4] and Becker et al. [5] found that the toxic values from the soil-block technique was higher in number than those from the agar-block technique. On the other hand, Bravery [6] said that both methods gave comparable toxic value results, but that differences have also been reported.

With the aim of explaining more precisely the differences between the agar-block and soil-block methods, comparative investigations were carried out by Amburgey [1] on pine using *Gloeophyllum trabeum*. After ten months exposure, the mass loss was only somewhat greater on the agar base, whereas the moisture content of wood was considerably higher on the soil base.

Extensive comparative investigations with the agar-block method according to the Polish standard [18], which is analogous to the DIN standard, and the soil-block method according to the Russian standard [12], were carried out by Ważny [26, 27, 28] and Ważny and Fedorov [30]. This work determined the toxic value of four preservatives (with most attention given to NaF) using *Coniophora puteana*. In all cases the soil-block method gave higher mass losses, final moisture contents of wood, and higher toxicity limits.

Monteiro *et al.* [17] compared decay by two white-rot and five brown-rot fungi in the soil and agar methods using *Pinus elliotii* and *Eucalyptus grandis*. Mass loss was decidedly greater in the soil-block method (2-3 times more), and the results were more homogeneous than on the agar base. Archer et al. [2] examined the toxic values of eight biocides against *G. trabeum*, *Postia placenta*, *Trametes versicolor* and *Irpex lacteus*. Results between the tests did not correlate well, and the toxic values within each method were also variable at times.

These published investigations show that there is – as hitherto – a lack of uniform view on the relationship between the toxic value results obtained in the agar-block and the soil-block methods. This paper looks at the agar-block and soil-block methods, by comparing the fungitoxic values obtained in the one laboratory with copper-chrome-arsenic (CCA) and a quaternary ammonium compound (QAC). This work was a continuation of the comparison between *Coniophora olivacea* and *Coniophora puteana* test strains under various culture conditions [29].

MATERIALS AND METHODS

The timber used was *Pinus radiata* D. Don sapwood blocks of the dimensions $20 \times 20 \times 15$mm. The preservatives were Bardac 22, a quaternary ammonium compound, and CCA (Tanalith C.) Solution concentrations were made by diluting with water, so that there were eleven retentions of active ingredient (0.3, 0.4, 0.5, 0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0 kg/m^3) for QAC, and seven retentions of total salt for CCA (0.3, 0.4, 0.5, 0.7, 1.0, 1.5, 2.0 kg/m^3). Blocks were treated using a vacuum of -88 kPa for 30 minutes, and 30 minutes at atmospheric pressure. Blocks were wrapped in plastic bags for two weeks to allow for chemical fixation to occur, and then air dried. There was no artificial weathering or leaching.

The jars used in this modified agar-jar and soil-jar tests were of 250 ml capacity, with metal screw-cap lids. Agar-jars were filled to one-third capacity with malt agar (2.5% agar, 4% malt extract). Soil-jars contained 100 g of "Toolangi forest soil" moistened to 60% moisture content, and two poplar feeder strips soaked previously overnight in 1% malt extract solution. All jars were autoclave sterilized.

The jars were inoculated with the test fungi:

Coniophora olivacea (Fr. ex Pers.) Karst. strain DEP 1779.

Coniophora puteana (Schum. ex Fr.) Karst. strain BAM Ebw. 15.

After about ten days fungal growth, wood blocks were sterilized by gamma-irradiation, and planted on feeder strips in the soil-jars. Sterile plastic mesh squares were placed in the agar-jars, and the sterile blocks placed on top of these. There was also a set of sterile controls. There were two blocks of identical preservative and concentration in each jar. Incubation was for 12 weeks at 23°C and 85% relative humidity. Blocks were then removed from jars, cleaned of surface mycelium and weighed to determine moisture content. They were conditioned to 12% MC, and weighed to determine mass loss.

Table 1

Comparing the toxic value by agar-block and soil-block methods
Porównanie wartości grzybobójczych uzyskanych metodą agarowo-klockową i ziemno-klockową

Test fungi Grzyby testowe	Toxic value in kg/m³ Wartość grzybobójcza w kg/m³	
	Agar-block method Metoda agarowo-klockowa	Soil-block method Metoda ziemno-klockowa
	Bardac 22	
C. olivacea	0.61[a] (0.50 - 0.70)[b]	2.5 (2.0 - 3.0)
C. puteana	0.70 (0.70 - 1.00)	1.2 (1.0 - 2.0)
	Tanalith C	
C. olivacea	0.48 (0.40 - 0.50)	1.2 (1.0 - 1.5)
C. puteana	0.49 (0.40 - 0.50)	>0.3 (?)

[a] According to PN 1961
Według PN 1961
[b] According to EN 1990
Według EN 1990

The fungitoxic value was determined from the graphical plots of the data, by looking for the retention where the mass loss was 3% (according to PN 1961; Cookson and Greaves, 1986), or by finding the retention interval between which the mass loss was greater than 3% and smaller than **3**% (according to EN 1990) (Table 1).

RESULTS & DISCUSSION

The mass loss results for QAC and CCA are presented in Figs. 1 & 2, and Table 1. The figures show the relationship between retention and mass loss. The toxic value of QAC against *C. olivacea* was 0.61 (0.5-0.7) kg/m^3 using the agar-block method, and 2.5 (2.0 - 3.0) kg/m^3 in the soil-block method. The toxic values were somewhat lower for *C. puteana*, but for this fungus the differences between the methods were smaller than for *C. olivacea.* In the agar-block method for *C. puteana* the toxic value was 0.70 (0.7 - 1.0) kg/m^3, and 1.2 (1.0 - 2.0) kg/m^3 in the soil-block method.

For CCA, the toxic value against *C. olivacea* was 0.48 (0.4 - 0.5) kg/m^3 in the agar-block method, whereas in the soil-block method the value was 1.2 (1.0 - 1.4) kg/m^3. With *C. puteana* the toxic value in the agar-block method

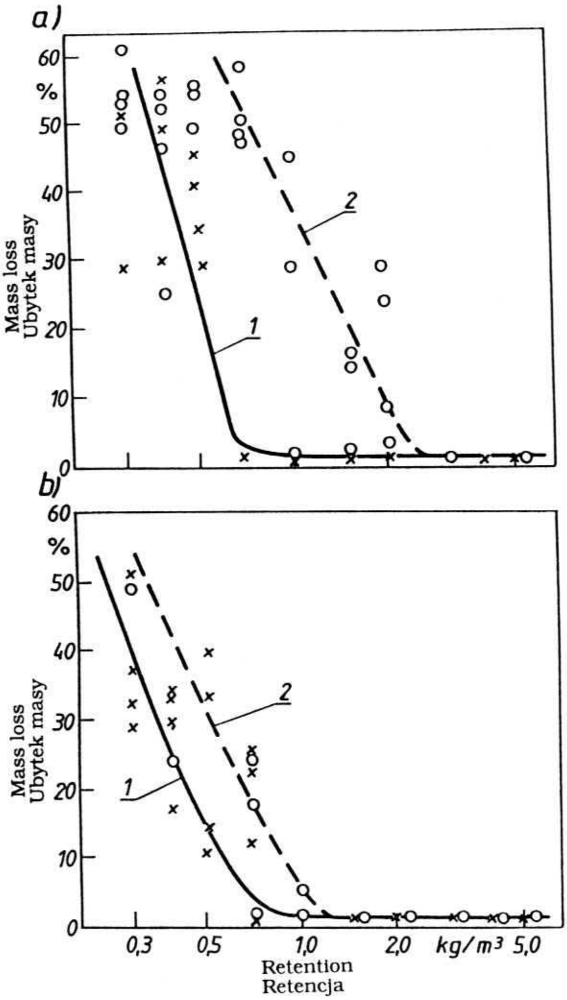

Fig. 1. Mass change of QAC-treated blocks exposed to *C. olivacea* (a) and *C. puteana* (b)
1 – the agar-block method, 2 – soil-block method

Ryc. 1. Ubytek masy próbek nasyconych QAC pod wpływem grzyba *C. olivacea* (a) i *C. puteana* (b)
1 – metoda agarowo-klockowa, 2 – metoda ziemno-klockowa

was 0.49 (0.4 - 0.5) kg/m^3, similar to that found for *C. olivacea*. However, the toxic value of CCA against *C. puteana* in the soil-block method was not determined, as there was no significant mass loss even at the lowest retention of 0.3 kg/m^3. It does not seem probable that the limit value was below this retention, but it is not known why decay in these jars was unsuccessful.

In order to explain the differences between the toxic values obtained with the agar-block and the soil-block methods, the final moisture content of the samples versus retention was plotted (Figs. 3 & 4). For. *C. olivacea*, the mean final moisture content of blocks in the soil-block method varied irregularly from 165% for untreated blocks and 139% for the lowest QAC retention

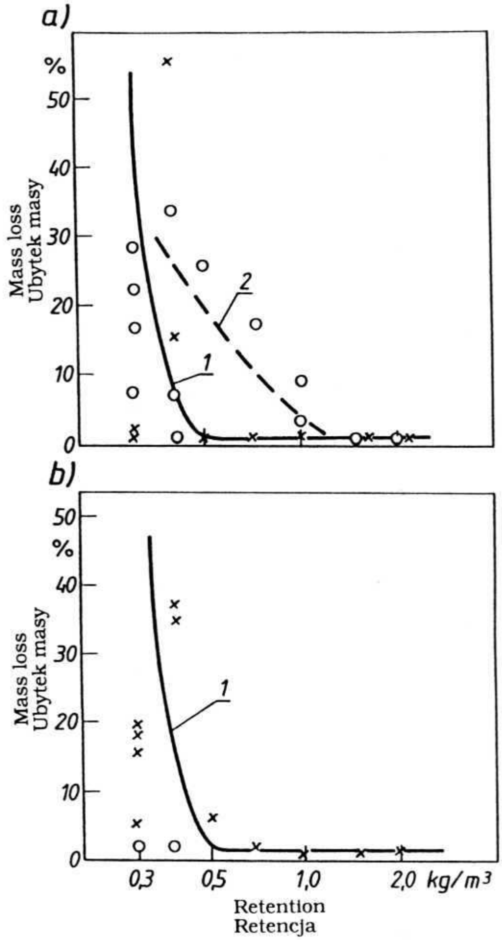

Fig. 2. Mass change of CCA-treated blocks exposed to *C. olivacea* (a) and *C. puteana* (b)
1 – the agar-block method, 2 – soil-block method

Ryc. 2. Ubytek masy próbek nasyconych CCA pod wpływem grzyba *S. olivacea* (a) i *C. puteana* (b)
1 – metoda agarowo-klockowa, 2 – metoda ziemno-klockowa

blocks, to 65.5% at the 5.0 kg/m^3 retention. CCA-treated blocks varied in moisture content from 126.0% to 58.2%. As for QAC, there was a trend for CCA-treated blocks to have lower moisture contents with higher retentions, due to the greater exclusion of decay. In the agr-block method the moisture content variation was much smaller for both QAC (ranging from 61.3% to 81.7%) and CCA (ranging from 46.7% to 68.8%).

For *C. puteana*, moisture content differences were smaller. In the soil-block method the untreated blocks had a mean moisture content of 156.7%, while QAC treated blocks ranged from 52.0% to 80.2%. On agar the blocks had even less variation, ranging from 59.5% to 99.2%, which was not very different for treated blocks to the moisture content found in soil-jars. However, there

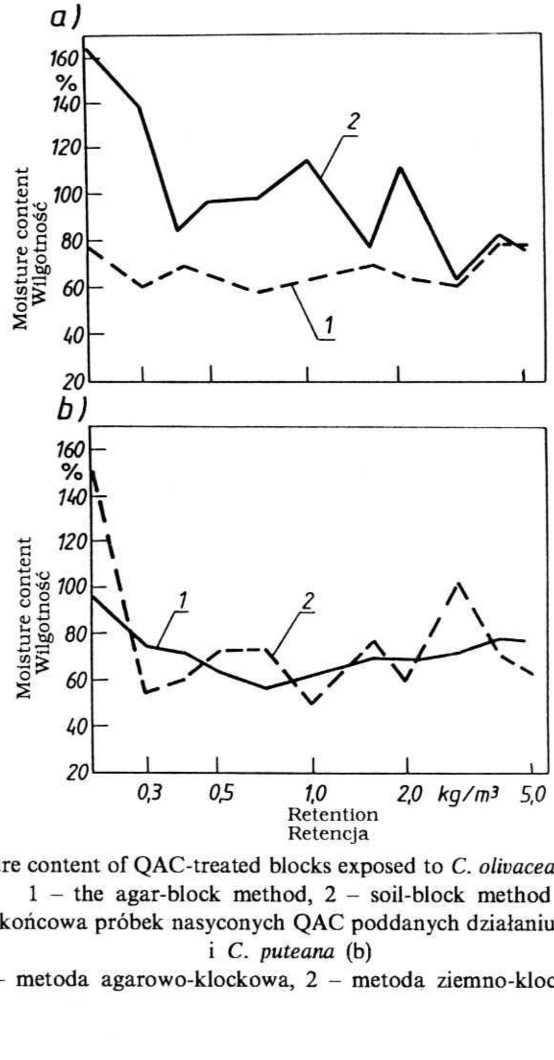

Fig. 3. Final moisture content of QAC-treated blocks exposed to *C. olivacea* (a) and *C. puteana* (b)
1 – the agar-block method, 2 – soil-block method

Ryc. 3. Wilgotność końcowa próbek nasyconych QAC poddanych działaniu grzyba *C. olivacea* (a) i *C. puteana* (b)
1 – metoda agarowo-klockowa, 2 – metoda ziemno-klockowa

was a difference in CCA treated block, according to which decay method was used. In the agar-block method moisture content varied from 85.5% to 111.5%, while all blocks in the soil-block method were with lower MCs of 45.5% to 56.6%.

The agar-block method tended to produce blocks with lower moisture content than in the soil-block method. *C. olivacea* seems to grow better in the soil-block method, whereas *C. puteana* grows as well or better in the agar-block method. Whether these different preferences are due to the different moisture content regimes, or the different mediums, is not known.

This study did not reveal a constant relationship between the two methods that would hold for both fungi. There were also differences between the two preservative types. Therefore the corresponding conversion coefficients

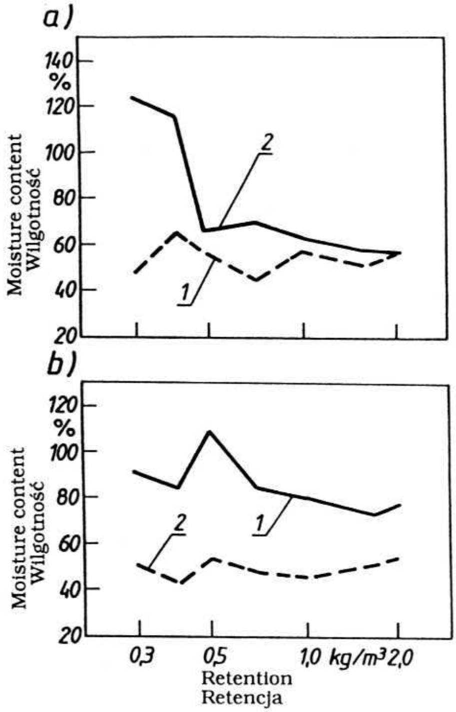

Fig. 4. Final moisture content of CCA-treated blocks exposed to *C. olivacea* (a) and *C. puteana* (b)
1 – the agar-block method, 1 – soil block method

Ryc. 4. Wilgotność końcowa próbek nasyconych CCA poddanych działaniu grzyba *C. olivacea* (a) i *C. puteana* (b)
1 – metoda agarowo-klockowa, 2 – metoda ziemno-klockowa

were impossible to find. It seems that only further extensive comparative investigations for each basic type of wood preservative will produce the assumptions needed to compare each type of preservative in the agar-block and soil-block methods.

Received in June 1994

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PORÓWNANIE METOD AGAROWO-KLOCKOWEJ I ZIEMNO-KLOCKOWEJ STOSOWANYCH PRZY OCENIE WARTOŚCI GRZYBOBÓJCZYCH ŚRODKÓW OCHRONY DREWNA

Streszczenie

Zastosowano zmodyfikowane metody agarowo-klockową i ziemno-klockową do porównania wartości grzybobójczej środków ochrony drewna typu QAC i CCA w stosunku do grzybów *Coniophora puteana* i *Coniophora olivacea*. Analizie poddano ubytek masy i końcową wilgotność próbek drewna.

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