Investigation of Leaching Performance of Wood Materials Colored with Walnut Husk

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Abstract

The purpose of this study to develop an eco-friendly wood stain alternative to synthetic dyes and to determine the desorption on wood surfaces. For this purpose; wood blocks was prepared from Turkish oriental beech (*Fagus orientalis* Lipsky), Scots pine (*Pinus sylvestris* L.), oak (*Quercus petraea* spp), and walnut (*Juglons regia* L.). Plant dyestuff was extracted from the Walnut husk by using ultrasonic assisted method. For mordants, ferrous sulfate ($Fe_2(SO_4)_3.7H_2O$), aluminum sulfate ($KAl_2(SO_4)_3.18H_2O$), copper sulfate ($CuSO_2.5H_2O$), and vinegar (CH_3COOH) were chosen and applied to wood blocks with immersion (classic) and immersion+ultrasonic assisted methods. To determine the stability of paint, the effect of such parameters as the medium pH (5, 7 and 9), temperature (22 and 40 °C), agitating speed (10 and 30 rpm) in leaching test was studied. Result showed that, generally aluminum sulfate and ferrous sulfate performed well desorption were reduced the desorption on all wood species surfaces.
Keywords: natural dye, Juglans Regia, walnut husk, leaching

1 Introduction

Wood is the oldest building materials that people use. There's plenty of it, it's relatively cheap, it's environmentally friendly, it looks great, it's warm and cozy, it's super-strong, it lasts hundreds or even thousands of years, and you can use it for everything from building bridges to making paper or heating your home.

Seasonal changes, effects of the sun and the rain causes an aged appearance on wood [1]. Wood coatings, varnish and impregnating chemicals are used to avoid this negative effect. However these chemicals respect to environmental health is reported in recent years [2]. Therefore, this subject; society, especially in this product customers, the administrative unit, has become a topic of industry professionals and researchers carefully followed [3].

In this study plant extracts will be used for coloring and protection of furniture. So our country has a great potential, but could not utilized of natural plant sources can be used and will arise new business areas. Thus, completely natural, with coloring properties but also harmless to the environment and human health, national origin and more economical surface treatment agents can be developed.

Today, many natural plant is used for dyeing textiles and food. These plants can be summarized as follows: Madder (*Rubia tinctorum* L.), walnut fruit outer shell (*Juglans regia* L.), chamomile (*Anthemis* sp.), sumac (*Rush coriaria* L.), hayıt (*Vitex agnus castus* L.), saffron (*Crocus sativus* L.), safflower (*Carthamus tinctorius* L.), henna (*Lawsonia inermis* L.), mint (*Mentha* sp.), acorn (*Quercus ithaburensis Decaısne*), India indigo (*Indigofera tinctoria* L.), red beet (*Beta vulgaris*), mastic tree, (*Pistacia palaestina*), mulberry (*Morus nigra*), licorice (*Glycyrrhiza glabra* L.), sage (*Salvia triloba*), blackberry (*Rubus canescens* DC.), and curcuma (*Curcuma longa* L.) [4,5].

Since ancient times, the natural sources used for dyeing. Today, many plant dyes are obtained and several scientific studies are done. Bechtold et al. (2007) [6]., used Canadian golden rod (Solidago vlrg aurea) for wool dyeing; Cristea and Vilarem (2006) [7]., used *Reseda luteola L.,* indigo *(Isatis tinctoria L.)* and madder root *(Rubia tinctoria)*for dyeing cotton yarn; Kamel et al., [8,9].Used lak insect (*Kerria lacca* Kerr) for dyeing wool

fabric, and cotton fabric; Göktaş et all (2008; 2009a; 2009b) [10,11,12]. used laurel (*Laurus nobilis* L.), oleander (*Nerium Oleander* L.), and madder root (*Rubia tinctorium* L.) for dyeing wood material.

2 Material and Method

2.1 Material

In this study, wood was prepared from Turkish oriental beech (*Fagus orientalis* L.), Scots pine (*Pinus sylvestris* L.), oak (*Quercus petraea* spp), and walnut (*Juglons regia* L.). Plant dyestuff was extracted from the *Juglans regia* L by using ultrasonic assisted method. To increase the extracts binding on the wood specimens, the material obtained with ferric sulfate ($Fe_2(SO_4)_3.7H_2O$), aluminum sulfate ($KAl_2(SO_4)_3.18H_2O$), copper sulfate ($CuSO_2.5H_2O$), and wine vinegar (CH_3COOH) mordants were used.

2.2 Method

2.2.1 Preparing wood blocks

Test samples prepared for leaching tests, from pine, beech, walnut and oak wood. Timber was marked according to TS 4176. Test sample has been prepared 19x19x19 mm measure and stored in climate cabinet at 20 ± 2 °C temperature and 65 ±5% relative humidity.

2.2.2 Dye material

In this study, the plants were dried in shade and ground. Plant particles mixed with distilled water having a 20/1 ratio of with 180W output power to a device is extracted in ultrasonic bath (45 °C, 180 minutes, Elmasonic X-tra 150 H). Diminishing evaporation of water is brought to the initial level by the addition of water.

2.2.3 Dyeing of the wood

The extraction is filtered with filter paper for separated from solid particles. Table 1 showed that the proportions of mordant agents. Wood test sample painted two different (classic and ultrasonic) methods (Table 2). Wood samples completely immersed in ultrasonic bath for dyeing and. At the end of time wood samples surface cleaned with a cloth and allowed to dry at room temperature in an upright position.

Table 1. Dye solution + mordant mixture ratios

Extracts	Mordant	Mixture (%)
Plant Extract	Control	0
	Ferrous sulfate	3
	Alum	5
	Copper sulfate	5
	vinegar	10

Table 2. Terms of dyeing wood samples

Dye stuffs	Ultrasonic output power (W)	Temperature (°C)	Time (min)
Plant Extract	Control (classical immersion)	45	60
	300	45	60

2.2.4 Leaching test

The aim of the study is impregnated with water-soluble natural paint on wood surface. In this process, the dye solution phase from the surface of the effect holding timber has many parameters. These parameters listed; type of wood, paint type, resolution, pH and temperature. So hold on to a solid surface is a highly complex process, it is necessary to carefully analyze all factors to ensure optimum plant design. These factors also holding mechanism determines the efficiency and yield.

3 Results

UV spectrophotometer was used in the leaching tests. Maximum wavelength and color intensity between wavelength was determined for walnut husk and mordanting concentrations (Table 3).

Table 3. Wavelength of dye

Type of Dye	Max. wavelength (nm)
Control (%100 *J. Regia*)	400
Walnut husk + Ferrous sulfate	369
Walnut husk + Alum	340
Walnut husk + Copper sulfate	362
Walnut husk + vinegar	382

3.1 Leaching data at pH: 5

According to Table 4; scotch pine, oriental beech, oak and walnut wood dyeing with classical and ultrasound methods using walnut shells, and different mordants for leaching tests result showed, the ferrous sulfate and

control (without mordant) group for scotch pine test samples dyeing with the classical method; the vinegar and aluminum sulfate group for oriental beech tests samples with classical method; the copper sulfate and aluminum sulfate group for oak tests samples with classical method and the control (without mordant) and aluminum sulfate group for walnut tests samples with ultrasonic method was observed more leaching. When examined Table 4, scotch pine test sample was dyed with ultrasonic method using ferrous sulfate mixture is minimum (0,087 abs), and maximum leaching showed ferrous sulfate with classical methods observed (0,183 abs) for scots pine test material. For oriental beech test sample was dyed with classical method with ferrous sulfate mixture and ultrasound method with vinegar mixture is showed (0,065 abs) minimum leaching, and maximum leaching was seen ultrasound method with copper sulfate (0,322 abs). Walnut test sample was dyed with classical method using vinegar mixture is minimum (0,077 abs), and maximum leaching showed aluminum sulfate with classical methods observed (0,303 abs) for walnut test material. Oak test sample was dyed with classical method using ferrous sulfate mixture is minimum (0,101 abs), and maximum leaching showed copper sulfate with ultrasound methods observed (0,212 abs) for oak test material.

3.2 Leaching data at pH: 7

In reference to Table 5; scotch pine, oriental beech, oak and walnut wood dyeing with classical and ultrasound methods using walnut shells, and different mordants for leaching tests result showed, the aluminum sulfate and copper sulfate group for scotch pine test samples dyeing with the ultrasound method; the ferrous sulfate and control (without mordant) group for oriental beech tests samples with classical method; the ferrous sulfate and vinegar group for oak tests samples with classical method, the control (without mordant) and vinegar group for walnut tests samples with classical method was observed more leaching. When investigated Table 5, scotch pine test sample was dyed with classical method using aluminum sulfate and cooper sulfate mixture are minimum (0,058 abs), and maximum leaching showed control (without mordant) with classical methods observed (0,131 abs) for scots pine test material. For oriental beech test sample was dyed with classical method with ferrous sulfate mixture is showed (0,041 abs) minimum leaching, and maximum leaching was seen ultrasound method with ferrous sulfate (0,131 abs). Walnut test sample was dyed with classical and ultrasound method using ferrous sulfate mixture is minimum (0,041 abs), and maximum leaching showed aluminum sulfate with ultrasound methods observed (0,346 abs) for walnut test material. Oak test sample was dyed with classical method using ferrous sulfate mixture is minimum (0,026 abs), and maximum leaching showed control (without mordant) with ultrasound methods observed (0,117 abs) for oak test material.

3.3 Leaching data at pH: 9

With respect to Table 6; scotch pine, oriental beech, oak and walnut wood dyeing with classical and ultrasound methods using walnut shells, and different mordants for leaching tests result showed, the ferrous sulfate, aluminum sulfate and copper sulfate group for scotch pine test samples dyeing with the ultrasound method; vinegar and control (without mordant) group for oriental beech tests samples with classical method; the ferrous sulfate, control (without mordant) and vinegar group for oak tests samples with classical method, aluminum sulfate and vinegar group for walnut tests samples with classical method was observed more leaching. When investigated Table 6, scotch pine test sample was dyed with classical method using aluminum sulfate mixture is minimum (0,106 abs), and maximum leaching showed copper sulfate with ultrasound methods observed (0,195 abs) for scots pine test material. For oriental beech test sample was dyed with ultrasound method with vinegar mixture is showed (0,071 abs) minimum leaching, and maximum leaching was seen ultrasound method with copper sulfate (0,288 abs). Walnut test sample was dyed with ultrasound method using ferrous sulfate mixture is minimum (0,074 abs), and maximum leaching showed aluminum sulfate with ultrasound methods observed (0,463 abs) for walnut test material. Oak test sample was dyed with ultrasound method using ferrous sulfate mixture is minimum (0,105 abs), and maximum leaching showed control (without mordant) with ultrasound methods observed (0,182 abs) for oak test material.

3.4 Leaching data at 40 ^{o}C temperature

In keeping with Table 7; scotch pine, oriental beech, oak and walnut wood dyeing with classical and ultrasound methods using walnut shells, and different mordants for leaching tests result showed, control (without mordant), aluminum sulfate and vinegar group for scotch pine test samples dyeing with the classical method; all group for oriental beech tests samples with ultrasound method; the

copper sulfate, control (without mordant) and vinegar group for oak tests samples with classical method, control (without mordant) and vinegar group for walnut tests samples with classical method was observed more leaching. When investigated Table 7, scotch pine test sample was dyed with ultrasound method using control (without mordant) mixture is minimum (0,118 abs), and maximum leaching showed copper sulfate with ultrasound methods observed (0,249 abs) for scots pine test material. For oriental beech test sample was dyed with classical method with ferrous sulfate mixture is showed (0,079 abs) minimum leaching, and maximum leaching was seen ultrasound method with copper sulfate (0,249 abs). Walnut test sample was dyed with classical method using control (without mordant) mixture is minimum (0,127 abs), and maximum leaching showed aluminum sulfate with ultrasound methods observed (0,448 abs) for walnut test material. Oak test sample was dyed with classical method using ferrous sulfate mixture is minimum (0,136 abs), and maximum leaching showed control (without mordant) with classical methods observed (0,276 abs) for oak test material.

3.5 Leaching data of shaking speed at 30 rpm

According to Table 8; scotch pine, oriental beech, oak and walnut wood dyeing with classical and ultrasound methods using walnut shells, and different mordants for leaching tests result showed, the ferrous sulfate, aluminum sulfate and copper sulfate group for scotch pine test samples dyeing with the ultrasound method; the ferrous sulfate, aluminum sulfate and copper sulfate group for oriental beech tests samples with ultrasound method; the ferrous sulfate, aluminum sulfate, control (without mordant) and vinegar group for oak tests samples with classical method, aluminum sulfate**,** copper sulfate and vinegar group for walnut tests samples with classical method was observed more leaching. When investigated Table 8, scotch pine test sample was dyed with ultrasound method using control (without mordant) mixture is minimum (0,071 abs), and maximum leaching showed copper sulfate with ultrasound methods observed (0,202 abs) for scots pine test material. For oriental beech test sample was dyed with classical method with ferrous sulfate mixture is showed (0,076 abs) minimum leaching, and maximum leaching was seen classical method with control (without mordant) (0,122 abs). Walnut test sample was dyed with ultrasound method using ferrous sulfate mixture is minimum (0,076 abs), and maximum leaching showed aluminum sulfate with classical methods observed (0,348 abs) for walnut test material. Oak test sample was dyed with classical method using aluminum sulfate mixture is minimum (0,120 abs), and maximum leaching showed control (without mordant) with classical methods observed (0,163 abs) for oak test material.

4 Discussion

In conformity with the leaching test result at pH: 5, the pine, beech and oak wood dyeing with walnut shell paint + ferrous sulfate mixture, and walnut dyeing with walnut shell + vinegar mixture was observed to least level. At pH:7 beech and oak dyeing with walnut shell + ferrous sulfate mixture , and the pine and walnut wood dyeing with walnut shell+ ferrous sulfate was observed to least level. At pH: 9 oak and walnut wood dyeing with walnut shell + ferrous sulfate mixture, pine wood dyeing with walnut shell + aluminum sulfate, and beech wood dyeing with walnut shell + vinegar was observed to least level.

At 40 °C the pine, and walnut wood dyeing with walnut shell paint + control mixture, and beech and oak dyeing with walnut shell + ferrous sulfate mixture was observed to least level. At shaking speed at 30 rpm, pine wood dyeing with walnut Shell + control mixture, beech and walnut wood dyeing with walnut shell + ferrous sulfate mixture, and oak wood dyeing with walnut shell + aluminum sulfate was observed to least level.

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Table 4. Leaching data of walnut husk at pH: 5 (abs)

Wood Type	Leaching Time (min)	Control		Ferrous sulfate		Alum		Copper sulfate		vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0,019	0,016	0,013	0,03	0,032	0,027	0,032	0,037	0,055	0,065
	15	0,043	0,081	0,032	0,069	0,048	0,038	0,093	0,089	0,061	0,071
	30	0,064	0,113	0,059	0,099	0,071	0,058	0,11	0,104	0,065	0,079
	60	0,078	0,125	0,071	0,133	0,097	0,065	0,14	0,118	0,088	0,085
	75	0,086	0,139	0,079	0,152	0,103	0,082	0,158	0,144	0,103	0,93
	90	0,094	0,142	0,083	0,176	0,119	0,085	0,161	0,156	0,098	0,097
	120	0,099	0,162	0,087	0,183	0,149	0,095	0,17	0,161	0,108	0,098
Beech	5	0,028	0,049	0,019	0,015	0,023	0,032	0,038	0,024	0,025	0,037
	15	0,031	0,055	0,024	0,027	0,028	0,04	0,136	0,055	0,031	0,044
	30	0,051	0,083	0,032	0,039	0,049	0,054	0,198	0,068	0,036	0,048
	60	0,054	0,091	0,039	0,051	0,053	0,068	0,252	0,086	0,041	0,054
	75	0,061	0,095	0,046	0,059	0,078	0,08	0,274	0,093	0,049	0,065
	90	0,064	0,103	0,058	0,06	0,086	0,094	0,292	0,11	0,056	0,068
	120	0,068	0,111	0,067	0,065	0,091	0,103	0,322	0,118	0,065	0,072
Walnut	5	0,042	0,033	0,019	0,005	0,047	0,065	0,034	0,076	0,062	0,046
	15	0,057	0,044	0,029	0,018	0,068	0,101	0,112	0,122	0,068	0,051
	30	0,071	0,068	0,041	0,026	0,111	0,147	0,137	0,159	0,072	0,045
	60	0,09	0,084	0,063	0,038	0,156	0,199	0,191	0,214	0,087	0,056
	75	0,092	0,09	0,074	0,044	0,188	0,226	0,212	0,229	0,112	0,070
	90	0,099	0,095	0,121	0,068	0,218	0,269	0,226	0,248	0,115	0,074
	120	0,113	0,11	0,142	0,088	0,260	0,303	0,251	0,257	0,120	0,077
Oak	5	0,046	0,042	0,008	0,009	0,030	0,027	0,030	0,024	0,035	0,042
	15	0,068	0,048	0,025	0,026	0,048	0,041	0,083	0,055	0,048	0,059
	30	0,097	0,075	0,034	0,033	0,067	0,061	0,100	0,072	0,064	0,064
	60	0,112	0,097	0,065	0,045	0,084	0,078	0,138	0,096	0,086	0,077
	75	0,128	0,106	0,082	0,061	0,102	0,110	0,159	0,112	0,107	0,094
	90	0,143	0,118	0,106	0,083	0,126	0,121	0,179	0,125	0,115	0,100
	120	0,155	0,132	0,134	0,101	0,143	0,132	0,212	0,134	0,129	0,117

U: ultrasonic method; C: classical method.

Table 5. Leaching data of walnut husk at pH: 7 (abs)

Wood Type	Leaching Time (min)	Control		Ferrous sulfate		Alum		Copper sulfate		vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0,030	0,059	0,024	0,055	0,025	0,019	0,028	0,031	0,018	0,029
	15	0,039	0,076	0,026	0,058	0,028	0,024	0,035	0,037	0,028	0,036
	30	0,045	0,098	0,036	0,063	0,033	0,032	0,046	0,042	0,035	0,043
	60	0,050	0,106	0,042	0,07	0,042	0,041	0,065	0,054	0,045	0,056
	75	0,057	0,117	0,046	0,075	0,046	0,046	0,074	0,066	0,052	0,068
	90	0,062	0,121	0,051	0,079	0,053	0,051	0,088	0,082	0,056	0,074
	120	0,067	0,131	0,058	0,086	0,061	0,058	0,101	0,091	0,065	0,083
Beech	5	0,03	0,044	0,057	0,012	0,011	0,019	0,019	0,017	0,022	0,025
	15	0,036	0,048	0,065	0,013	0,019	0,024	0,044	0,027	0,028	0,032
	30	0,042	0,058	0,085	0,019	0,032	0,036	0,049	0,038	0,033	0,033
	60	0,051	0,068	0,100	0,025	0,035	0,044	0,057	0,042	0,036	0,036
	75	0,055	0,073	0,110	0,029	0,038	0,049	0,062	0,049	0,041	0,037
	90	0,061	0,081	0,123	0,034	0,045	0,052	0,064	0,054	0,043	0,041
	120	0,068	0,085	0,131	0,041	0,050	0,058	0,073	0,057	0,053	0,045
Walnut	5	0,039	0,048	0,009	0,011	0,071	0,044	0,023	0,023	0,022	0,025
	15	0,051	0,063	0,013	0,015	0,099	0,063	0,038	0,033	0,032	0,040
	30	0,067	0,080	0,020	0,021	0,137	0,075	0,048	0,039	0,043	0,045
	60	0,081	0,089	0,021	0,032	0,224	0,114	0,073	0,057	0,051	0,056
	75	0,085	0,099	0,029	0,034	0,265	0,120	0,081	0,062	0,054	0,066
	90	0,089	0,105	0,036	0,035	0,298	0,130	0,086	0,066	0,059	0,069
	120	0,093	0,111	0,041	0,041	0,346	0,166	0,109	0,075	0,066	0,077
Oak	5	0,045	0,048	0,011	0,006	0,017	0,028	0,025	0,022	0,033	0,043
	15	0,052	0,072	0,015	0,015	0,034	0,029	0,036	0,024	0,039	0,055
	30	0,065	0,080	0,018	0,017	0,039	0,032	0,045	0,032	0,043	0,063
	60	0,087	0,091	0,026	0,021	0,042	0,040	0,059	0,043	0,056	0,074
	75	0,093	0,099	0,029	0,021	0,047	0,046	0,061	0,046	0,062	0,082
	90	0,099	0,103	0,031	0,020	0,052	0,050	0,066	0,049	0,065	0,089
	120	0,110	0,117	0,034	0,026	0,058	0,058	0,074	0,057	0,070	0,093

U: ultrasonic method; C: classical method.

Table 6. Leaching data of walnut husk at pH: 9 (abs)

Wood Type	Leaching Time (min)	Control		Ferrous sulfate		Alum		Copper sulfate		vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0,032	0,069	0,037	0,029	0,024	0,029	0,067	0,074	0,044	0,059
	15	0,064	0,098	0,064	0,063	0,056	0,063	0,090	0,085	0,067	0,085
	30	0,078	0,116	0,083	0,056	0,077	0,069	0,124	0,122	0,079	0,092
	60	0,093	0,138	0,111	0,086	0,086	0,085	0,155	0,153	0,088	0,107
	75	0,098	0,140	0,127	0,096	0,095	0,091	0,185	0,163	0,109	0,115
	90	0,108	0,142	0,161	0,121	0,112	0,105	0,188	0,176	0,112	0,118
	120	0,115	0,152	0,189	0,143	0,128	0,106	0,195	0,190	0,124	0,124
Beech	5	0,032	0,024	0,056	0,015	0,035	0,028	0,053	0,039	0,013	0,049
	15	0,046	0,030	0,070	0,030	0,054	0,046	0,063	0,053	0,030	0,067
	30	0,055	0,047	0,075	0,037	0,059	0,044	0,132	0,068	0,039	0,071
	60	0,070	0,086	0,081	0,048	0,083	0,059	0,255	0,083	0,043	0,075
	75	0,081	0,095	0,089	0,056	0,085	0,059	0,288	0,085	0,061	0,090
	90	0,089	0,103	0,101	0,064	0,090	0,070	0,283	0,099	0,065	0,092
	120	0,094	0,113	0,114	0,081	0,106	0,079	0,288	0,113	0,071	0,097
Walnut	5	0,047	0,053	0,014	0,026	0,084	0,058	0,066	0,042	0,043	0,066
	15	0,069	0,049	0,035	0,029	0,162	0,124	0,095	0,053	0,062	0,083
	30	0,084	0,091	0,034	0,031	0,210	0,147	0,131	0,070	0,069	0,096
	60	0,099	0,107	0,053	0,045	0,312	0,222	0,180	0,098	0,078	0,104
	75	0,106	0,118	0,046	0,052	0,354	0,246	0,195	0,106	0,102	0,122
	90	0,113	0,124	0,063	0,072	0,385	0,282	0,223	0,126	0,096	0,122
	120	0,124	0,133	0,074	0,099	0,463	0,338	0,258	0,150	0,104	0,134
Oak	5	0,059	0,071	0,014	0,025	0,026	0,030	0,045	0,046	0,050	0,062
	15	0,085	0,097	0,030	0,041	0,056	0,059	0,055	0,062	0,069	0,076
	30	0,100	0,114	0,036	0,046	0,059	0,065	0,076	0,079	0,082	0,084
	60	0,126	0,147	0,042	0,052	0,088	0,091	0,116	0,098	0,085	0,095
	75	0,134	0,159	0,050	0,058	0,096	0,103	0,124	0,108	0,100	0,111
	90	0,146	0,167	0,083	0,081	0,106	0,116	0,147	0,125	0,111	0,121
	120	0,182	0,172	0,109	0,105	0,126	0,129	0,155	0,136	0,127	0,131

U: ultrasonic method; C: classical

Table 7. Leaching data of walnut husk at 40 °C temperature (abs)

Wood Type	Leaching Time (min)	Control		Ferrous sulfate		Alum		Copper sulfate		vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0,053	0,103	0,054	0,048	0,049	0,052	0,086	0,082	0,041	0,078
	15	0,063	0,133	0,076	0,066	0,070	0,073	0,120	0,110	0,055	0,111
	30	0,074	0,153	0,093	0,088	0,106	0,105	0,160	0,135	0,068	0,127
	60	0,081	0,169	0,124	0,112	0,127	0,130	0,208	0,157	0,091	0,151
	75	0,097	0,196	0,158	0,122	0,136	0,141	0,227	0,172	0,113	0,170
	90	0,105	0,203	0,169	0,121	0,139	0,152	0,235	0,193	0,121	0,174
	120	0,118	0,218	0,184	0,143	0,148	0,167	0,249	0,206	0,137	0,182
Beech	5	0,070	0,047	0,041	0,016	0,052	0,037	0,074	0,047	0,047	0,042
	15	0,092	0,065	0,051	0,019	0,057	0,045	0,104	0,069	0,062	0,050
	30	0,095	0,074	0,060	0,035	0,089	0,065	0,148	0,093	0,078	0,060
	60	0,102	0,087	0,105	0,049	0,100	0,084	0,186	0,113	0,095	0,069
	75	0,124	0,101	0,110	0,057	0,103	0,088	0,201	0,124	0,102	0,079
	90	0,124	0,116	0,118	0,066	0,123	0,096	0,227	0,135	0,108	0,081
	120	0,143	0,125	0,136	0,079	0,144	0,111	0,249	0,144	0,121	0,089
Walnut	5	0,054	0,087	0,028	0,031	0,101	0,113	0,082	0,094	0,051	0,052
	15	0,072	0,111	0,047	0,048	0,144	0,147	0,110	0,129	0,068	0,074
	30	0,085	0,124	0,077	0,055	0,216	0,211	0,152	0,167	0,089	0,107
	60	0,093	0,143	0,134	0,119	0,314	0,278	0,210	0,217	0,113	0,147
	75	0,110	0,155	0,143	0,143	0,360	0,302	0,223	0,224	0,130	0,172
	90	0,119	0,172	0,192	0,165	0,413	0,344	0,257	0,257	0,142	0,181
	120	0,127	0,174	0,276	0,221	0,448	0,383	0,270	0,281	0,158	0,194
Oak	5	0,083	0,105	0,032	0,022	0,041	0,045	0,052	0,044	0,023	0,067
	15	0,118	0,144	0,055	0,055	0,056	0,058	0,075	0,069	0,047	0,086
	30	0,137	0,164	0,090	0,093	0,088	0,086	0,104	0,095	0,111	0,111
	60	0,149	0,189	0,131	0,101	0,118	0,107	0,137	0,124	0,143	0,144
	75	0,189	0,222	0,156	0,116	0,130	0,120	0,151	0,138	0,160	0,164
	90	0,198	0,237	0,167	0,124	0,147	0,139	0,193	0,151	0,175	0,177
	120	0,229	0,276	0,211	0,136	0,168	0,155	0,234	0,166	0,207	0,211

U: ultrasonic method; C: classical

Table 8. Leaching data of shaking speed at 30 rpm (abs)

Wood Type	Leaching Time (min)	Control		Ferrous sulfate		Alum		Copper sulfate		vinegar	
		U	C	U	C	U	C	U	C	U	C
Scots pine	5	0,024	0,055	0,012	0,013	0,033	0,029	0,054	0,052	0,033	0,049
	15	0,039	0,075	0,024	0,025	0,060	0,049	0,098	0,076	0,047	0,072
	30	0,043	0,086	0,039	0,044	0,074	0,058	0,134	0,117	0,058	0,090
	60	0,055	0,108	0,064	0,065	0,098	0,081	0,175	0,141	0,049	0,110
	75	0,065	0,119	0,075	0,077	0,109	0,087	0,188	0,151	0,090	0,112
	90	0,070	0,124	0,075	0,075	0,120	0,097	0,206	0,163	0,084	0,118
	120	0,071	0,134	0,084	0,072	0,135	0,116	0,202	0,156	0,086	0,120
Beech	5	0,037	0,043	0,017	0,004	0,025	0,029	0,038	0,032	0,041	0,040
	15	0,050	0,060	0,023	0,018	0,044	0,045	0,067	0,053	0,060	0,054
	30	0,060	0,076	0,034	0,028	0,057	0,055	0,074	0,061	0,067	0,060
	60	0,081	0,095	0,057	0,048	0,082	0,075	0,094	0,072	0,082	0,074
	75	0,083	0,102	0,068	0,056	0,087	0,079	0,095	0,075	0,086	0,081
	90	0,085	0,110	0,076	0,061	0,087	0,089	0,104	0,079	0,095	0,084
	120	0,096	0,122	0,081	0,076	0,100	0,093	0,110	0,091	0,093	0,089
Walnut	5	0,034	0,047	0,002	0,010	0,052	0,063	0,043	0,038	0,034	0,049
	15	0,044	0,066	0,010	0,028	0,087	0,112	0,083	0,064	0,054	0,077
	30	0,058	0,077	0,030	0,062	0,122	0,164	0,102	0,087	0,070	0,095
	60	0,076	0,098	0,060	0,111	0,182	0,253	0,131	0,110	0,090	0,118
	75	0,081	0,106	0,063	0,124	0,210	0,290	0,148	0,118	0,098	0,128
	90	0,084	0,109	0,069	0,138	0,234	0,320	0,165	0,130	0,106	0,137
	120	0,094	0,118	0,076	0,161	0,278	0,348	0,197	0,148	0,112	0,150
Oak	5	0,046	0,052	0,024	0,022	0,036	0,034	0,052	0,048	0,046	0,042
	15	0,064	0,071	0,047	0,048	0,063	0,051	0,082	0,073	0,072	0,058
	30	0,086	0,087	0,069	0,071	0,081	0,071	0,100	0,090	0,081	0,064
	60	0,108	0,113	0,102	0,109	0,113	0,092	0,129	0,122	0,110	0,088
	75	0,117	0,130	0,110	0,118	0,134	0,100	0,141	0,134	0,120	0,100
	90	0,128	0,141	0,117	0,121	0,140	0,108	0,147	0,142	0,129	0,113
	120	0,147	0,163	0,131	0,136	0,159	0,120	0,158	0,150	0,154	0,126

U: ultrasonic method; C: classical

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