Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(6): 70-74
Received: 13-09-2017
Accepted: 14-10-2017

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Variation in wood specific gravity of selected tree species of Kohima district of Nagaland North Eastern parts of India

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Abstract
The basic quality indicator for most of the wood properties is wood density and moisture content. Wood density steadily has the most influence on mechanical properties, particularly stiffness. It has an influence on many of the mechanical/physical processes during manufacture. A study was conducted to determine moisture content, wood specific gravity and ash content of branch and stem samples of most commonly found 15 species of Kohima, Nagaland. Findings of the present study revealed significant variation between branch and stem for different parameters. The study showed that the species with the highest moisture content for both stem and branch was *Albizia chinensis* (60.88% and 63.11%) while minimum was in *Quercus pachyphylla* (31.16 and 32.05%), maximum ash content in branch of *Terminalia myriocarpa* (2.68%)while stem ash content was higher in *Cedrela serrata* (0.65%). Minimum ash content recorded in *Albizia procera* (1.34%) and M*acaranga peltata* (0.26 %) for branch and stem respectively. The species with maximum specific gravity found for the branch sample was *Quercus serrata* (0.69) and the minimum was in *Alnus nepalensis* (0.35) whereas stem samples of *Quercus serrata, Quercus pachyphylla* and *Myrica nagi* recorded highest specific gravity (0.70) while the minimum was exhibited by *Alnus nepalensis* (0.36).

Keywords: wood specific gravity, moisture content, ash content, branch, stem and variation

Introduction
Wood is an important natural resource which is renewable and is used in the everyday life of human beings in every walk of life from building houses and making tools to making furniture and fuel. Wood also store carbon and help in decreasing carbon dioxide in the atmosphere. Specific gravity is the basic standard of comparison among species and wood product and is very closely related to many mechanical properties of wood like crushing and bending strength and hardness with denser wood being stronger. In the last few years, plant biologists have started taking an interest in wood specific gravity as they search for broad-spectrum functional traits and determine their ecological and evolutionary significance (Muller-Landau, 2004; Chave *et al*., 2006; Swenson and Enquist, 2008) [17, 24, 5]. Wood specific gravity is important in accurately estimating carbon stocks of forests. (Chave *et al*., 2005; Baker *et al*., 2004) [4, 2]. Wood specific gravity is an important variable in estimating carbon stock of forests. It correlates to carbon density per unit volume and is important in estimating ecosystem carbon storage (Brown, 1997; Fearnside, 1997; Mani and Parthasarathy, 2007) [3, 7, 12].
Many factors contribute to variations in specific gravity within a wood species. The extractives found in wood such as resins and gums, can cause a variation in specific gravity. The location of the wood sample within a tree (i.e., juvenile or reaction wood), the geographic range of the tree species, site conditions where the tree grew, and tree genetics can also cause specific gravity to vary. Variation in density is found along the bole, among species, and among individuals in any given species due to differences in the age of the tree and in the climatic life zone (Wiemann and Williamson, 1989, 2002; Woodcock, 2000; Baker *et al*., 2004; Muller-Landau, 2004) [17, 2, 31]. This variation reflects the interaction of the plant with environmental factors, such as climatic and edaphic conditions, natural impacts and competition for light (Wiemann and Williamson, 1989; Muller-Landau, 2004) [17]. Basic density or specific gravity is a key variable for the estimation of tree mass. The rule is that the basic density of branch wood decreases in the direction from the branch to its top.

Materials and method
The present study was conducted on different wood samples collected from Kohima district of the North –East India.

Kohima is located at 25º40'N to 25.67ºN and 94º07'E to 94.12ºE with an average elevation of 1261 metres (4137 feet), covers an area of 1,463 sq. km**.** The present study involved the collection of wood samples from 15 tree species in the study area. The samples were collected by cutting cross from branch and main bole sections from the same species. Wood specific gravity within individual trees often varies vertically along the main axis of the stem and/or radically from the pith to the bark. For each tree species, three samples each of the cross section and branch samples were taken from mature trees of different girth classes and the mean of the three samples were considered as the specific gravity of that species.

An appropriate tree was chosen. The trees were in the range 10-30 cm in DBH. The trunk was cut at a height of 20-30cm with the cut disc 2 inches in thickness. The discs were further cut into smaller wedges to enable easier handling.

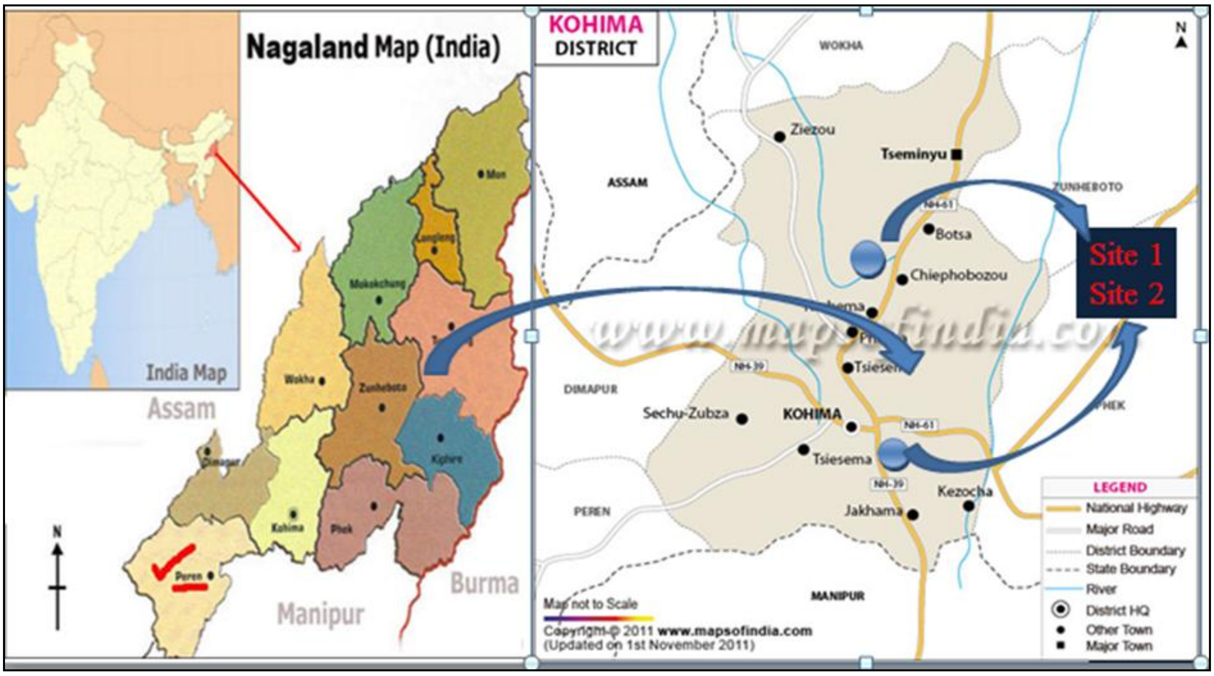

Fig 1: Map of study sites

Measuring Moisture content (%)

For the estimation of moisture content of the species, each sample was weighed using digital weighing machine after collection and placed in an oven heated to 101 °C to 105 °C (214°F to 221°F). The samples were weighed at regular interval until constant weight was achieved. (Reeb and Milota, 1999)

$$Moisture\ content\ \% = \frac{Fresh\,weight - Oven\ dry\ weight}{Fresh\,weight} \times 100$$

Estimation of ash content (%)

The ash content was determined according to AOAC (Association of Analytical Chemists, 2005) [1]. Two grams of each sample of oven dried tree sample was added into a pre-weighed crucible and put in the muffle furnace and incinerated in muffle furnace at 600 °C for 5-6 hours and then placed in a dessicator for 30 minutes. After cooling, the crucible along with the ash was weighed and the ash content was estimated using the formula:

$$Ash(\%) = \frac{W_3 - W_1}{W_2 - W_1}$$

Where, W_1 is the weight of cleaned, dried, ignited, and cooled crucible, W_2 the weight of the crucible and sample, and W_3 the weight of the crucible and sample after incinerating at 600 °C and cooling in an airtight homogenized vessel.

Measuring specific gravity

The specific gravity of each species was calculated using wood samples as per the mentioned calculation,

$$\text{Specific gravity} = \frac{\text{Weight of oven dry wood}}{\text{Green volume of wood}}$$

For measurements of green volume, the Archimedes principle method, where the measured weight of displaced water was taken as equal to the sample's volume (Chave, 2005) [4] Oven-dry weight was measured from the same sample by drying it in a hot air oven until it attained constant weight.

Results and discussion

The moisture content of the samples were differ significantly and maximum moisture content recorded for branch being *Albizia chinesis* (60.88%) followed by *Alnus nepalensis* (59.45%) and *Quercus pachyphylla* having recorded the least moisture content (31.16%) for branch samples. The moisture content for the main stem samples for which *Albizia chinensis* with 63.11% had the highest moisture content followed by *Alnus nepalensis* with 61.92.%, while *Quercus pachyphylla* had the least with 32.05%. *Albizia chinensis* which had the maximum moisture for branch samples had higher moisture content as the fibres are saturated and the cell wall holds more water. Lignin is a comparatively hydrophobic molecule and

the ability of the walls to take up water is limited in part by the presence of lignin. Moisture content also varies with latitude and longitude (Al-Sagheer and Devi Prasad, 2010).
The results from the table (Table 1) show that the maximum ash content for the branch samples was found to be *Terminalia myriocarpa* (2.68%) while *Albizia procera* (1.34%) exhibited the least ash content. The stem samples, *Cedrela serrata* (0.65%) recorded maximum ash content, whereas the species exhibiting minimum ash content was *Macaranga peltata* (0.26%). There was significant difference found in both the branch sample and the stem sample. *Terminalia myriocarpa* which had the highest amount of ash content for the branch samples as it contain higher amount of living matter than the other species which had lesser ash content than it. Variation between the ash content of the branch samples and the ash content of the stem samples stem was observed, with the branch samples recording higher ash content than the stem samples. This is because, the branch samples have higher amount of living tissue than the stem samples. And ash content is known to increase with increase in height of tree with bark and branches recording higher ash content than stem samples (Wang and Dibdiakova, 2014) [25].
Ash content measures the amount of extractives in wood which is also a factor which affects specific gravity of wood.
The specific gravity of the branch samples has recorded significant variation in different species and highest specific gravity was recorded in *Quercus serrata* (0.69) followed by *Myrica nagi* (0.67). The species with the least specific gravity was found in *Alnus nepalensis* (0.35). *Quercus pachyphylla*, *Myrica nagi* and *Quercus serrata* exhibited maximum specific gravity (0.70) for stem. The minimum was found to be *Alnus nepalensis* (0.36). The mean average specific gravity of *Quercus sp.* (0.70) had similar results with Reyes *et al* (1992) [20] but was found to be higher than the reported value in Wood Handbook (USDA Forest Products Lab 1978). For the stem samples, *Quercus serrata* was reported at 0.78 by Meetei *et al* (2015) [16]. The reason for the high value of specific gravity observed in *Quercus* spp is because of higher volume of cell wall material and volume of Lumina of those cells.
The stem samples were found to have slightly higher specific gravity then the branch samples. This was because basic density of trees increases with decreasing width of growth rings (Skovsgaard, 2011) [22] which happens because wood basic density increases as the proportion of cells with thick cell walls increases.

Table 1: Dry weight, Moisture Content, Ash Content, Volume and Specific gravity of the samples

Species	Dry weight (kg)		Moisture content (%)		Ash content (%)		Volume of sample (cm³)		Specific gravity	
	Branch	Stem	Branch	Stem	Branch	Stem	Branch	Stem	Branch	Stem
Albizia chinensis	0.032	0.041	60.88	63.11	2.01	0.29	61.160	77.00	0.53	0.55
Macaranga peltata	0.026	0.046	51.54	54.76	1.62	0.26	58.39	94.67	0.44	0.48
Alnus nepalensis	0.031	0.035	59.45	61.92	1.86	0.36	89.43	98.00	0.35	0.36
Ziziphus incurve	0.040	0.086	31.55	35.05	2.08	0.53	62.36	196.67	0.65	0.66
Schima wallichii	0.043	0.110	33.01	38.52	2.06	0.33	68.59	168.67	0.63	0.65
Quercus pachyphylla	0.071	0.107	31.16	32.05	1.48	0.27	105.86	93.07	0.66	0.70
Pyrus pashia	0.034	0.084	33.10	36.37	2.61	0.63	62.42	124.31	0.65	0.69
Myrica nagi	0.053	0.068	38.73	40.19	2.49	0.49	78.35	97.67	0.67	0.70
Terminalia myriocarpa	0.068	0.055	44.02	45.98	2.68	0.32	13.43	106.67	0.49	0.52
Phyllanthus emblica	0.036	0.103	41.74	32.50	1.88	0.33	57.64	154.33	0.63	0.65
Cedrela serrata	0.036	0.059	50.19	50.85	2.01	0.65	84.23	131.33	0.43	0.45
Quercus serrata	0.095	0.117	31.33	34.01	2.50	0.49	138.92	168.66	0.69	0.70
Betula alnoides	0.043	0.039	48.68	52.97	1.53	0.28	95.77	84.33	0.45	0.46
Albizia procera	0.063	0.043	35.23	38.37	1.34	0.34	109.47	71.67	0.58	0.60

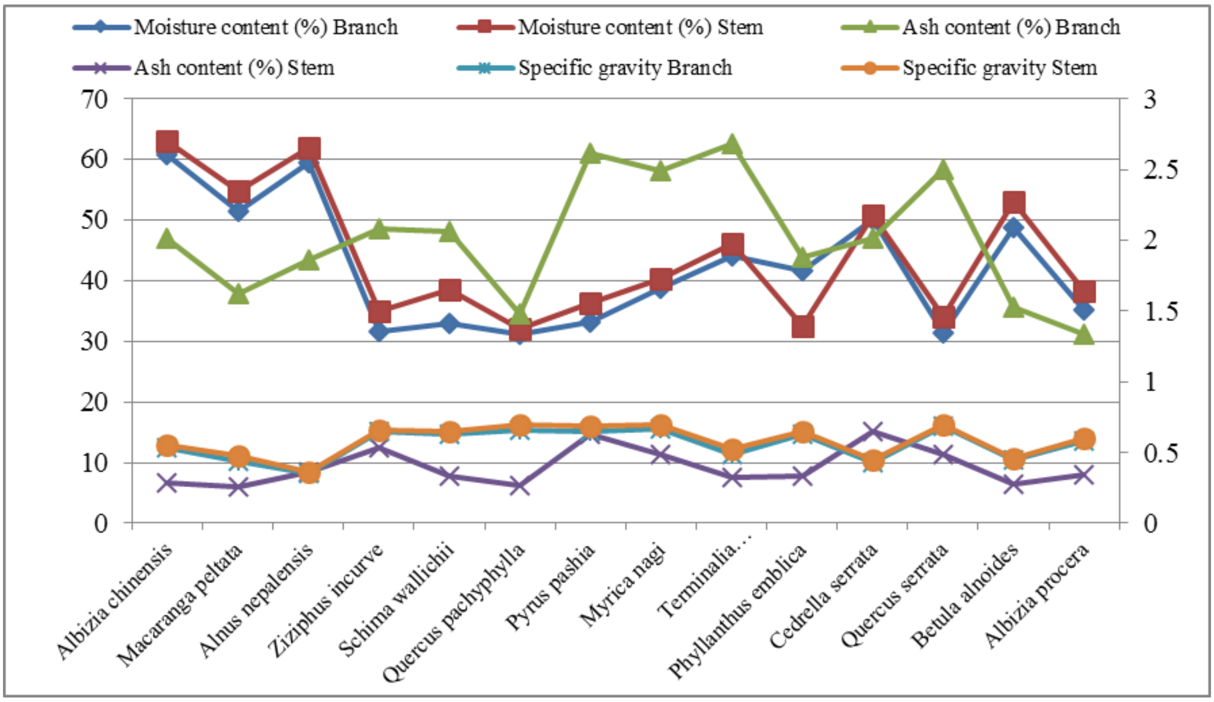

Fig 2: Dry weight, Moisture Content, Ash Content, Volume and Specific gravity of the samples

Conclusion

The findings of present study showed that the species with the highest moisture content for both stem and branch was *Albizia chinensis* (60.88% and 63.11%) respectively while minimum was in *Quercus pachyphylla* (31.16 and 32.05%), *Terminalia myriocarpa* (2.68%) and *Cedrela serrata* (0.65%) recorded maximum ash content for branch and stem respectively whereas minimum ash content recorded in *Albizia procera* (1.34%) and M*acaranga peltata* (0.26%). The maximum specific gravity was recorded in *Quercus sp.* (0.70) while the minimum was recorded in *Alnus nepalensis* (0.36). The measurement of wood specific gravity is not a new subject but the availability of this data for trees is still very less and not well known especially in the North eastern region of India.

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