Study of stinging nettle (urtica dioica l.) Fibers reinforced green composite materials: a review

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Abstract. Stinging Nettle (Urtica dioica L., latin) is a wild plant that grows in Indonesia, Asia, and Europe. Nettle in Bali, Indonesia is called as Lateng, Jelatang. Nettle plant has a very strong fiber and high fixed carbon. Nettle plants are covered with fine hairs, especially in the leaves and stems. When it is touched, it will release chemicals, sting and trigger inflammation that causes redness, itching, bumps and irritation to the skin. Nettle plants grow in the wild, regarded as a weed in the agricultural industry, easy to grow and snatch food from the parent plant. The main objective of this paper is to review of the potential nettle fibers and then explain about the potential of local nettle plant in Indonesia. Nettle is a plant group at the end of bast. Its plant fibers taken from the bark, as reinforcement in composite materials. Nettle fibers have three main advantages such as strong, lightweight and low environmental impact.

1. Introduction
Natural fiber reinforced polymer composites is a term used in composites journals as a term in producing developed materials from polymer that is reinforced by natural fiber. Natural fiber has a great impact as a potential substitute for synthetic conventional fiber such as aramid and glass fiber during the last decade. Because of the mechanic characteristics of natural-polymer fiber, namely: good in isolation, low density, non-abrasive, easily obtained from renewable materials, cheap in price and can be recycled, it has attracted the composite industry for automotive application, structure and non-structure. Glass fiber that is difficult to be decomposed triggers serious health and environment problems. They cannot be recycled easily by heat because they melt in very high temperature and still produce residues that may spoil the environment and are relatively abrasive in nature, as what are mentioned in the result of some studies [1-5]. The main focus of this study is to find out the potency of natural fiber of stinging nettle as the replacement of glass fibers as reinforced composite fibers.

1.1. Classification of Natural fibers
Natural fibers from plantation can be divided into six categories, namely: bast, leaf, seed, fruit, grasses/reeds, & wood fibers. Table 1, shows the hierarchy of the fibers variation and their family.

Table 1. Natural Fibers/Plant Fibers[6].
### Classification

| Field of application | Use | Part of the plant |
|----------------------|-----|-------------------|
| **Textile/fiber**    | Tissues and fabrics, ropes and fishing nets, silky fabric, biocomposites, paper and cloth, paper, natural dye (for yams, eggs, etc.) | Fiber tissues of stems. Root and leaf extracts for dyes |
| **Medicine**         | Anaemia, gout, rheumatism, eczema, hypoglycaemia, diuretic, hypotension, benign prostatic hyperplasia, arthritis, cardiovascular problems, allergic rhinitis, antiviral, antifungal, and antioxidant, antimicrobial, antiulcer analgesic [8]. | Leaves, roots, aqueous, seeds and alcoholic extracts |
| **Cosmetics**        | Soap, skin lotion and shampoo | |
| **Food**             | Salad, pier, decocted tea, soups and natural yellow colorant for egg yolk [9]. | Leaves, young plant |
| **Forage crop**      | Cattle, poultry, horses, and pigs for enhancing yolk yellowness | Whole plant |
| **Animal housing**   | Bedding, lactating dairy cows [10]. | Stem, shivers as fiber by-product and seeds |
| **Bioenergy**        | Biochar | |

### Table 2. Potential uses of stinging nettle

1.2. The Usefulness of Stinging Nettle

Stinging nettle is classified into shrubs with 30–45 species. Stinging nettle grows in fertile soil and it grows until 40 up to 120 cm in height. Stinging nettle as natural biomass, the applications that have been developed are in livestock, medicine, cosmetics and fibers.

### 2. Method

Stinging nettles have been being cultivated by some countries have been investigated in term of mechanic performance in which taking place in France, Tuscani, Netherland and India.

2.1. Material

Stinging nettles which were used in this study were harvested in France, Brittany Region [11]. Those stinging nettles were cultivated in 1-2 years, the study was done in Prato (43°53’N, 11°06’E) Tuscany region [12]. Stinging nettles fiber are taken from Brennels BV, Kraggenburg, The Netherlands, fibers from Urtika dioica L. clone B13, cultivated in the Netherlands, harvested in August-September 2007 [13].
2.2. Sample preparation
Stinging nettle stems were cut and dried for two days before they were decayed in the water for seven days. Those stinging nettle stems were dried in room temperature for weeks. The fibers were extracted manually [11]. The stems of cultivated stinging nettle were tested on its ends, middle, and [12]. Fibers extraction were done in 4-6 weeks, done mechanically in the same July 2008 for decortications rami and flax [13].

Several works have been done by many researchers on stinging nettles composite study as shown in table 2 for potential uses of stinging nettles, table 3 for the tensile strength of the composite reinforcement fibers, table 4 for the diameter, length, tensile strength and elongation of fiber according to the position on the stem nettle, table 5 for the chemical composition, morphology, and mechanical properties of fiber extraction results, table 6 for influence of different fiber of the loads on the mechanical characteristics of compression molded on PLA (poly lactic acid) composites without adhesion promocers.

3. Result and Discussion of Mechanical Properties
Research results Bodros, as shown in Tabel 3, stinging nettle has the highest ultimite stress among the nature fibers that is 1594 (± 640) MPa. It means that if the stinging nettle fiber is used as composite material it will produce composite with a great strength.

| Name             | Young’s modulus (Gpa) | Ultimate stress (MPa) | Strain to failure (%) | Density (g/cm³) | Average diameter (μm) |
|------------------|-----------------------|-----------------------|-----------------------|-----------------|-----------------------|
| Stinging nettle  | 59-115                | 2274-914              | 2.92-1.3              | 0.72            | 24.3-15.5             |
| Flax ariane      | 73-43                 | 1825-853              | 3.31-3.23             | 1.53            | 23.6-12.0             |
| Flax Agatha      | 96-46                 | 1800-962              | 2.9-1.3               | 1.53            | 15.6-14.4             |
| Hemp             | 21.6-16.6             | 310-230               | 0.9-0.7               | 1.48            | 36.1-26.3             |
| Ramie            | 24.5                  | 560                   | 2.5                   | 1.51            | 34                    |

Specific weight of stinging nettle that is 0.72 gram/cm³ categorized as light fiber [12]. With light average specific weight, if stinging nettle is used as composite reinforcement there is a potency that it will produce a light and strong material.

| Name        | Bottom | Middle | Top |
|-------------|--------|--------|-----|
| Diameter (μm) | Mean 47 | 32     | 19  |
|             | Range 31-63 | 21-42 | 10-26 |
| Length (mm)  | Mean 43  | 50     | 58  |
|             | Range 27-60 | 39-63 | 40-73 |
| Tensile Strength (cN tex⁻¹) | Mean 24  | 62.1   | 58.7 |
|             | Range 12-40 | 38-98 | 24-98 |
| Elongation (%) | Mean 2.6 | 2.3    | 2.5  |
|             | Range 1.5-3 | 1.3-3.5 | 1-6  |
Stinging nettle fiber that is taken from the middle of the stem has better tensile strength and elongation as shown in Table 4. Most of natural fibers contain lignin-cellulose, but they also contain other components such as hemicellulose, pectin, hardwood, ash, silica, oil, wax & other water solutions. So many things to learn in order to understand the individual concentration of each component if natural fiber composite is produced. Cellulose is semi-crystalline polysaccharide, while hemicellulose is a highly branched amorphous polymer. In order to produce adhesion strength between fiber and matrix minimum ash and wax elements are needed, wax reduce adhesion. Hydroxyl group from cellulose within the natural fiber describes natural hydrophilic, that reduces the bond between faces and makes composite absorbs water easily.

Table 5. Chemical composition, morphology, and mechanic characteristics of extracted fiber [13]

| Treatment | CR | D | WR | D+WR | WR+D | MR | D+MR | ET | ET+CA |
|-----------|----|---|----|------|------|----|------|----|-------|
| Cellulose (%) | 81 | 65 | 78 | 83 | 85 | 78-84 | 75-85 | 80-82 | 81-83 |
| Hemicellulose (%) | 6 | 5 | 9 | 13 | 6 | 9-10 | 5-7 | 11-12 | 11-12 |
| Lignin (%) | 2 | 3 | 2 | 4 | 2-5 | 3-4 | 2-3 | 2-3 |
| Diameter (μm) | 23-37 | 23-47 | 37-41 | 40-46 | 29-43 | 24-31 | 16-40 | 30-40 | 25-35 |
| Length (mm) | 38-62 | 25-58 | 37-41 | 38-58 | 35-55 | 41-55 | 33-65 | 7-98 | 21-72 |
| Tensile strength (cN tex⁻¹) | 38-81 | 70-182 | 8-94 | 41-83 | 23-71 | 33-65 | 7-98 | 21-72 | 32-76 |
| Elongation (%) | 4-7 | 2-3 | 2-4 | 1-3 | 1-2 | 2-4 | 0-2 | 3-6 | 3-6 |

Methods which were used to take the fiber include: chemical retting (CR), decortication (D), water retting (WR), microbiological retting (MR), enzymatical treatment (ET), chelating agent (CA).

Table 6. Influence of different fiber loads on the mechanical characteristics of compression on moulded PLA (Poly lactic acid) composites without adhesion promoters [14].

| Fiber | Fiber load in wt-% Note | Tensile strength in MPa | Tensile modulus in GPa | Elongation at break in % | Flexural modulus in GPa | Impact strength in kJ/m² |
|-------|--------------------------|-------------------------|------------------------|--------------------------|------------------------|--------------------------|
| Nettle | 20 Press pressure 5.6 MPa, maintained for 20 min at 175 °C, fibres were oriented predominantly in length direction | 45 | 4.8 | 1.2 | 4.2 | 14 |
| | 30 | 59 | 5.6 | 1.5 | 5.2 | 11 |
| | 40 | 40 | 4.8 | 1.3 | 4.6 | 6 |
| Hemp | 34 Fiber length 5-15 mm; random fiber orientation | 41.1 | 5.65 | 7.4 |
| | 44 | 44.6 | 3.7 | 7.0 |
| | 55 | 8.3 | 1.0 | 7.3 | 0.9 |
| Flax | 30 Enzyme retted fibers; random fiber orientation | 53 | 8.3 | 7.3 |
| | 40 | 40 | 4.3 | 7.0 |
| Jute | 34 Water cleaned fibre. | 39.5 | 8.3 | 1.0 | 18.5 |
| | 44 Fibre length 5-10 mm | 42.0 | 7.3 | 0.9 | 23.5 |
| | 55 random fibre orientation | 43.0 | 7.3 | 0.9 | 32.0 |
Research on composite tensile strength was done by combining PLA with some natural fibers (nettle, hemp, flax and jute). It is shown that the highest tensile strength of nettle is 59 MPa, with weight fraction 30%.

Natural fiber that was given chemicals to erase lignin and enrich the adhesion strength between fiber and matrix can be seen in literature [17-21]. Meanwhile the textbook that explains about composite materials can be seen in literature [22-24]. The development of studies and cultivation of nettle in some countries are discussed in literature [25-27].

Figure 1. Stinging nettle plants
Figure 2. Stems of nettle

Figure 3. Stems that have been marinated in the water and the fibers are out
Figure 4. Nettle stinging fibers
Figure 1 until 6 is nettle plants which are available in Indonesia that have been SEM tested on its stems and fiber, we will apply chemical treatment with local nettle to increase the strength and toughness of the composite materials.

4. Conclusion
The potency of stinging nettle to be used as reinforcement of composite materials is so great, it can be seen from the result of the study that was conducted by the researcher. The fibers were taken from the stems of the nettle. Some treatments with chemicals on nettle fiber are needed to be done, form example on flax, hemp and ramie, and to reinforce the fiber and the bound between fiber and matric.

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