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Alternative Construction Materials for Furniture Production

Associate Professor Dr. Inga Valentinienė[1, a] and Dipl.-ing. Giedrius Pilkis[2, b]

[1, 2] Kauno kolegija/Kaunas University of Applied Sciences, Pramones av. 20, Kaunas, Lithuania.

Abstract

The present article of ecological design is created and applied to the furniture sector, which until recently was considered one of the most anti-ecological industries.In the article, the following phenomena of the manufacturing and realization of ecological products, which have become the crucial starting points in the creation of furniture designs from natural fibres, are analysed: proper usage of structural materials and fittings for furniture production, increase of energy efficiency, optimization of transport services, promotion of local materials and local production, and assurance that the product

will be utilized safely or reused. This is a new niche of ecological design, a missing link in the chain of growing and processing fibrous materials and the synergy of various industries, agriculture and even medicine.

Keywords: furniture design and production, eco materials, flax nettle hemp fiber

INTRODUCTION

The aim of the current article is to contribute to the resolution of an important problem caused by the situation in the current world of industry – excessive exploitation and pollution of nature due to the manufacturing of new products.

RELEVANCE.

One of the most significant social topicalities at the beginning of this millennium is the concern for the fate of humanity and all life on Earth. According to ecologists and other scientists, the humanity has already reached a critical point in impoverishing and devastating its planet. As a response to such human activity that has negative consequences, nature is presenting the humanity with more and more natural disasters and, due to this, the living conditions in many developing countries (the so called "third world countries", which exploit their natural resources for the development of mass industrial production) have become hardly bearable or are about to become such.

Nature has always played and will play the most important part in a person's life. While conducting their practical activities, the humanity has always maintained or has been forced to maintain a close relationship with nature and its resources. The human kind's treatment of nature has always been effected by the prevailing attitude towards its natural phenomena and resources. However, has the humanity chosen the right ethical values, if the course it has taken and the current situation are leading towards a catastrophe?

Significant changes in the humanity's thinking which emphasize ethics and demand for a humanistic basis in all people's activities emerged only in the end of the 20th century. Even the conception of humanism itself has transformed, thus now a human being is considered to be not the ruler of nature, but its intellectual part only. The German biologist Ernst Haeckel introduced the term ecology into the scientific terminology in 1866, and this expanded the horizon of the ecological ethics.

For a very long time nature was understood only as a source and means of satisfying human needs. In contrast, now we have human ecology, social ecology, and global ecology.[1] Economic, social and cultural peculiarities of human life have penetrated the relationship between the humanity and nature. Sadly, it took 100 years after the term ecology had emerged, to start modernizing production technologies and reorganizing economies into ecological ones. The oldest environmental label is the Blue Angel, which saw its beginning in Germany in 1977. It inspired other countries in Europe and beyond to follow Germany's example and create national or regional systems of marking environmentally friendly products. The highest need to register ecological farms and ecological activities of industrial companies officially arose in Europe only in 1990. In 1991, the European Agriculture Council of Ministers adopted the Regulation (EEC) No. 2092/91 „regarding the ecological production of agricultural products <...>"[2]. The EU countries have prepared 20 criteria for the award of the eco-labelling to product groups, which are constantly reviewed and developed by taking the latest scientific achievements into account.[3] Now the Eco-Label system is applied to 26 product groups (including textile products, paints, paper, detergents, household appliances and services).[4]

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[1] *Kalenda, Č., Ekologinė etika: ištakos ir dabartis. Vilniaus universiteto leidykla, 2002. – 277 p. – ISBN 9986-19-463-6*

[2] *Official Journal of the European Union. REGULATIONS.COMMISSION REGULATION (EC) No. 889/2008. 5 September 2008*

[3] *<http://www.savas.lt/zalios-zinios/2086-ekologiniai-zenklai-europos-sajungoje-ir-lietuvoje.html>*

[4] *www.ec.europa.eu/environment/pubs/pdf/factsheets/scp/lt*

Even though the idea of ecological production has spread, a significant part of industrialists still fail to comprehend the importance of ecology or simply ignore it. According to ecologists, the situation needs to change now, due to the risks to the environment and human health. Nevertheless, today there are more sceptics of ecological production and usage of such products than those who support it. In the Western society, alternative materials and energy sources are becoming more popular and can be applied. However, many producers still view their costs as repelling. Nonetheless, we live in a multi-layered world, thus there are many manufacturers who think about the future and start implementing the principles of ecological production in the industry or service sections, because they understand that eco-products provide a possibility to maintain their position in the global and regional markets later on. Many global corporations follow such examples by significantly changing their operative strategy and choosing renewable sources of energy.

An example of the latter is the Swedish company IKEA, which always integrates functionality, quality, design and, undoubtedly, the standards of sustainability in their business development. The company follows this conception in every step: by creating their designs, choosing suppliers of raw materials and packages. IKEA entered Lithuania in 1992 through the cooperation with the then company AB Jonavos baldai, and soon became the biggest customer in the Lithuanian furniture industry. In 2015, the Lithuanian industrialists were announced as the fourth IKEA producers in the world, based on the amount of products manufactured. Having in mind the fact that companies from virtually all around the world manufacture furniture, lamps and various household items for the IKEA group, the fourth position in the map of suppliers for the pedantically demanding global network is a significant and valid achievement.

The local internal policy and the global policy both will undoubtedly force the industrialists to solve ecological problems provided they want to remain competitive in the market.[5] The journal of the European Commission Smarter and Cleaner states that the so called green public procurements can significantly affect the support of new products, ecological technologies and innovations.[6] Ten underlying groups of products and services, to which green public procurements are applied, have been determined. [7]: 1. Constructions; 2. Food industry and catering services; 3. Transport; 4. Electricity; 5. Office IT equipment; 6. Textile products; 7. Copying and graphic paper; 8. Furniture; 9. Cleaning supplies and services; 10. Garden supplies and services.

A competitive ecological product should, first of all, emerge in the minds of planners and design specialists. The aim of an ecological design is not only to sell such a product but also to raise the awareness of users and expand the issue of environmental protection, in order to prevent it from becoming a problem solved only by a group of the most interested people. Each product designer should take this into account and it should influence their production and realization from the start till the end of exploitation.

The term of ecological design can be applied to two fields: social sciences, when ecological systems (intangible ideas (projects)) are created and implemented, and design and architecture, when ecological products (tangible objects from household items to buildings, elements of urban infrastructure and landscape surfaces) are created and manufactured.

These two areas of ecological design are joined by the overall idea to balance such an environment, which would satisfy the needs of today but would not limit the ability of future generations to satisfy theirs".[8]

By applying this concept, we must take the responsibility for possible positive or negative outcomes for the environment and society, look for new ideas and technological solutions, and apply high-standard environmental norms and rules to industrial design and entire industry both.

PROBLEM

The current ecological design art project has been created and applied to the sector of „Furniture".[9] Until recently, this sector was one of the most anti-ecological ones. Manufacturers of furniture and other interior objects use finishes, paints, glues and other types of chemicals, which contribute to the interior air pollution significantly. This pollution is caused by gases which are emitted by the wooden furniture, drapery and other structural materials saturated with chemicals. It was impossible to suspect that a bigger dosage of pollution reaches our lungs not through the exhaust gas of vehicles (hydrocarbon (HC), carbon monoxide (CO) and nitric oxides (NOx)), but through the formaldehyde emitted by cabinet furniture. The formaldehyde emission can spread hazardous substances from the products for more than 10 years. Before Lithuania regained independence, the production of chipboards (RCB) included binding agents, which emitted the staggering 10-20 mg of formaldehyde from 100 g of dry wood (class E2). These toxins cause numerous diseases and allergies and enter the air as easily as most hazardous substances do. In 1985, the World Health Organization declared RCB to be a carcinogen that might cause various types of cancer. Moreover, it irritates the mucous membranes of eyes, nose

[5] The Strategy of Economic Factors in Environmental Protection. http://ukmin.lrv.lt/
[6] European Commission. Smarter and Cleaner. Luxembourg: Office for Official Publications of the European Communities, 2010. ISBN 978-92-79-15749-3.
[7] <http://ec.europa.eu/environment/gpp/index_en.htm>
[8] Sim Van der, R., Cowan, S., Ecologicalal design, United States of America: Island Press, Suite 300, 718 Connecticut Ave., NW, Washington, DC 20009, 2007. ISBN-13: 978-1-59726-140-1.
[9] <http://ec.europa.eu/environment/gpp/index_en.htm>

and larynx, and a high concentration can induce asthma attacks. After the company Girių bizonas was modernized in 1997, class E1 binding agents were introduced into chipboard production. The latter means two times lower amount of formaldehyde emitted. The amount of formaldehyde was further reduced to E1/2 class in 1999, when IKEA joined the company's management. Thus the situation has been improving significantly, but an ecological production of RCB without any formaldehyde compounds still remains unthought-of.[10]

RCB has always been and will be a very marketable material in furniture manufacturing, because it is cheap, easily processed, and there is a number of ways to do it. The usage of this board in household is not the only problem.

The issue of ecology becomes relevant again when the furniture must be utilized: the period of its natural disintegration is relatively long, and it emits hazardous substances even more actively when burnt.

The manufacturing of upholstered furniture encompasses the usage of foam and synthetic materials, which not only accumulate electrostatic charge during exploitation, but emit highly toxic gases as well. What is more, upholstered furniture cannot be called ecological, because it is constructed from numerous different structural elements: the carcass from natural wood, boards, staples, wood screws and other connecting and softening elements. Their assemblage and later utilization are very uneconomic due to the fact that they require extensive manpower, electricity and time input, special infrastructure and transport.

Moreover, even an item made from natural wood is rarely ecological because of the following reasons: forests are cut down for its production, glue for binding the battens are used due to its constructive peculiarities, details are connected with metal or plastic fittings. Furthermore, the wood for mass production of natural wood furniture in Lithuania is often imported from foreign countries (Russia, Belarus, Ukraine and Poland). Thus the cost of transportation is added, time is wasted and the atmosphere is polluted.

The features of ecological furniture or other interior eco-objects has to be strictly taken into account and defined as follows:

- recycled materials are used;
- same type materials are used;
- the product's construction requires a minimum or none of
- attachment fittings;
- in structures, glue is not used or organic natural glue is
- used;
- -finishing and protective materials containing no toxic
- substances are used;
- minimal easily recycled or degradable packaging is used;
- local production which prevents the cost of fuel for
- transportation, is organized.

METHODOLOGY

The idea that the aim of this project was to create a new ecological structural material and an innovative product from it suitable for industrial scale manufacturing, significantly influenced the research. Thus it had to comprise the theoretical and practical (testing) approaches both. While deepening theoretical knowledge, the comparative method popular in humanities was used together with the statistical method and the method of qualitative data analysis applied in social sciences.

The technological experiments and tests were performed in manufacturing companies under the leadership of experienced technologists. An obvious realization followed that the birth of the idea and the formation of the design vision are impossible without a broad humanitarian perspective and the comprehension of the realm of culture. However, it was also understood that a designer's visions must be practically tested in manufacturing laboratories, the practitioners of which base their work on the chemical, physical and mechanical knowledge. The active, sincere communication with the manufacturers, newly found professional acquaintances and creative relationship with practitioners and theoreticians both played their role also.

SCIENTIFIC ORIGINALITY

Taking the ecological problems of the "Furniture" sector into account, an ecological, degradable, harmless material, which provokes innovative design forms, has been created from such renewable fibrous plants as flax, nettle and hemp (growing naturally in Lithuania) and patented 11 by Vilnius Academy of Arts. This material can be used in producing interior objects for the closest surroundings of people. In the construction of such objects, one type material and a minimum of attachment fittings are used.

The pursuit to create products (structural materials and interior eco-objects) from secondary raw materials, renewable energy sources and ecological and economical elements solves critical problems. Analyzing separate phenomena of ecological production and realization, the fundamental supporting points in designing furniture from natural fibres, were formulated:

[10] In RCB production, glue is necessary to bind wooden particles (chips), because the tiny particles do not bind by themselves even during the hot-pressing in high pressure. While producing fibreboards (MDF, HDF) during dry or wet processes, wooden fibres are too short and thus have to be bound with additional chemical binders.

- the amount of manufacturing materials has been reduced:

types of materials are not mixed, details are attached with fitting, which is mounted without additional manufacturing operations and which does not have to be utilized or recycled later on;

- recycled, environmentally friendly and non-toxic materials are used;
- energy efficiency is increased: the chosen manufacturing method requires less energy and less economic resources
- maximum quality, functionality and durability of the product is achieved: long-term and more effective products are replaced more rarely than low-quality items, and a longer life of a product decreases its surplus in the material environment;
- a manufacturing method requiring less transport services (the product is manufactured locally from local materials) is applied;
- utilization and/or repeated usage of the product are ensured.

I. CHARACTERISTICS OF LOCAL FIBROUS PLANTS AND THEIR APPLICABILITY TO THE PRODUCTION OF STRUCTURAL MATERIALS

Fibrous plants are a source of raw materials which grow naturally in Lithuania, are alternative to wood and suitable to produce structural elements. The natural conditions of our country are appropriate for growing only the following long-fibre crops: flax/linseed (lot. Linum usitatissimum), stinging nettle (lot. Urtica dioica) and hemp (lot. Cannabis sativa) [12]. The value of the said long-fibre plants lies in the following facts: they can be used for the production of structural elements as a "building" material, their mass made of high-quality fibres is suitable for industrial processing, and they possess natural adhesive (cellulose) properties. Their stems produce two types of raw materials, which may be used industrially: boon and fibres. Both of these types are suitable for the production of such structural materials as fiberboards. This is an ecological advantage, because other industries such as the textile industry use only fibres (boon is used for fuel production or are discarded).

Flax, nettle and hemp are long-fibre plants, whose fibres contain big amounts of cellulose: flax – 65-90% of cellulose, the length of fibres – up to 65 mm; nettle – 86.5% of cellulose, the length of fibres – up to 75 mm; hemp – 88.3% of cellulose, the length of fibres – up to 55 mm, compared to wood which contains only 50% of cellulose and the length of fibres in conifers is 3-7 mm, and in deciduous trees – only 1-2 mm. The cell width is 0.04-0.08 mm13. The fibres of fibrous plants contain a lot of cross nodes, longitudinal striations or additional hairs that help to create a more solid cellulosic netting which, in its turn, directly affects the resistance of fibrous products to physical impact.

Not only scientists but businesspeople also have understood that the demand for products having positive (ecological, antiseptic, light, etc.) properties is rapidly growing. The legalization of hemp grown for fibre in Lithuania on 1 January 2014 was followed by an intense search for possibilities to use hemp stems, because the lack of realization methods in this agricultural area means it is not worth to grow them. The cultivation of hemp as cellulosic raw material would present the farmers with numerous possibilities, create new employment and protect the national forests. The industrial application of natural fibres should increase, because the markets of specialized textile and bioplastic[11] and the application of natural fibres in the automotive industry[12] are expanding.

II. FEASIBILITY STUDY OF PRODUCING STRUCTURAL MATERIALS FROM FIBROUS PLANTS BIOMASS

All experimental testing was conducted by strictly keeping to the boundaries of the project's aim and a strong direction from the trial of raw materials to the formation of structural elements.

Cellulose molecules have a linear structure and a high molecular mass, which determines the irreversible deformation (plasticity) and strength of fibres. In these plant origin polymers, all micro fibrils that compose macromolecules are affected more or less equally by the tensile forces, thus the strength of such fibrous materials is very high during pulling. The flax, nettle or hemp fibre mass comprises more than 85% of cellulose, and the average degree of polymerization is extremely high (for instance, 30 000 in flax).

The cellulose fibres are one of the most hygroscopic fibres. This can be understood as a disadvantage in terms of structural fibrous materials: with an increase of humidity, the material's elasticity increases, i.e. it does not maintain the initial form. In order to eliminate this problem, paraffin is used by mixing it into the biomass of fibres. Moreover, flax, nettle and hemp possess good elongation characteristics. If a fibre is able to elongate under a certain load, its ability to withstand impact and multiple loads increases, thus the products which are characterized by a higher reversible deformation maintain their initial form better and do so for longer periods.

[11] Alberta Hemp Cost of Production and Market Assesment. Final Report. Serecon Management Consulting Inc, Edmonton, Alberta: 2012

[12] Wood-Plastic Composites (WPC) and Natural Fibre Composites (NFC): European and Global Markets. WPC/NFC Market Study. Nova-Institute for Ecology and Innovation: 2014.

The wet process of fibreboard production suits the manufacturing of ecological sheet structural materials the most. The said process differs from the dry one, because in this case the inter-adhesion of fibres is achieved by applying chemical hydrogen bonds between the cellulose molecules instead of using adhesive substances (synthetic resins). The matrix structure secures its form and is sufficiently strong, especially in the high density fibreboards. If the biomass is not purposefully pressed by applying additional force and the water can drain out by itself, low density (light) structural elements of solid form, which break easily while being broken, but are not generally frail and maintain the form that has been given to them well, are formed. This material can be used for the production of lampshades, decorative elements and other interior design objects of non-supporting structure.

The performance of industrial scale testing during which hot presses were used showed that the wet process technology applied while manufacturing wooden fibreboards is suitable for manufacturing flax, nettle and hemp fibreboards. Products from fibrous plants' biomass maintain the forms obtained while pressing in their hot state and natural state (after cooling), too. Curved elements formed from flax, nettle and hemp biomass are suitable for the same purpose as the curved elements made from wooden fibreboards.

The compositional material from organic reinforcing agents and natural polymeric binders acquire features characteristic to plastic and become a low-density, light material, easily formed in high temperature and maintaining the given form in a natural state, more easily fracturing when mechanically affected by a force higher than the one intended for its exploitation, but recycled without any harm to the environment, because all its compositional elements are organic. During the laboratory testing, the scientists of the Ukrainian Institute of the Chemistry of Polymeric Bonds proved that a possibility to produce polymeric eco-plastic binders from hemp seed oil. Such ecological eco-plastic structural materials can be used to manufacture interior (maybe even exterior?) volumetric design eco-objects.

III. DESIGN IDEAS FOR INTERIOR ECO-OBJECTS FROM PLANT ORIGIN BIOMASS AND TECHNOLOGICAL ACHIEVEMENTS OF ECOLOGICAL PRODUCTION. REVIEW OF ANALOGUES

More and more examples of eco-objects, made from such innovative self-decomposing materials as biopolymers, bio-fibreboards and bioplastic appear. Scientists find more and more methods of binding the particles of biological origin with natural adhesive plant materials.

It is said that "It is easy to be different, but difficult to be better", but almost all designers presented in the present part of the art project have received global acclaim and such international awards as Red Dot, Geneva Invention Award, WIPO Award, Pentaward and others for their ecological design solutions, inventions of alternative structural materials and the support for the philosophy of sustainability. Such well-known furniture companies as Magis, Calligaris, Cartell and Emeco have become the supporters of ecological design. What is more, a world-renowned designer Philippe Starck cooperates with prominent companies by conveying the knowledge of ecological design and personal experience.

Good examples of saving trees are becoming more and more apparent. Chipboards can be made from agricultural waste: straws, flax, maize stems, sugarcanes, rice, palms, bamboo waste, rape seeds, various grasses, shells of sunflower seeds or nuts. Up to 30% of energy can be saved while making fibreboards from straws.

The number of companies that obtain bioplastic from plant oils is increasing. It might turn into a certain revolution in the production of interior and even exterior design objects. The analogues of plastic furniture could be produced from a composite of plant fibres and bioplastic. They can be homogenous, thus only a small amount of energy is used for their manufacturing and utilization. They are easy to transport and store, and this is as ecological as it is cost-saving.

While evaluating the design of interior eco-objects, made from the plant fibre biomass, it was noticed that the technological "flexibility" of structural eco-materials is best revealed through the form of objects being created. Designers usually choose almost primitive or ethnical replication of interior objects. However, the copying of "modern" classic or even the efforts to play with geometric forms and futuristic insights are also often observed. All these design solutions nowadays are innovative and sometimes even provoking. This is especially applicable to objects that have a "rough" and "messy" image, which creates a special contrast with the "sterile" surrounding in the homes of big city residents. The combination of natural and artificially created colors presents the feeling of the technological and aesthetical applicability of eco-objects in modern spaces. Designers choose their colors and structures carefully and try to secure the balance of the "eco-message" being conveyed. Usually a natural and open exposure of the object's texture prevails and the latter helps the creator to strengthen the aforementioned didactic mission and performs an educational function – demonstrates the structural material, comprehended not only through seeing but through touching also.

IV. TECHNIQUES OF FORMING AND PROCESSING THE STRUCTURAL MATERIALS FROM THE FIBROUS PLANT BIOMASS

The experimentation helped to test and prove that the structural materials from fibrous plants can be of two types:

1. Sheet material – fibreboards, manufactured by applying the wet board formation process;

2. Volumetric elements – when the dewatered biomass of particles is formed by applying high-pressure in spatial forms. Both types of materials can be processed using the usual equipment for wood and its products and by applying the known and operational technologies.

The trial and analysis of the possible techniques for manufacturing and processing the structural materials from the biomass of fibrous plants in our country, it can be stated that interior and furniture designers have a wide range of possibilities to implements their ideas, but two significant shortcomings still exist. Firstly, there are no possibilities to manufacture configured and volumetric objects from plant biomass. Secondly, ecological alternatives for synthetic resins, such as bioplastic produced from plant oils, water-based binders etc., do not exist in Lithuania.

GENERAL CONCLUSIONS

1. In order to investigate the theoretical and practical possibilities to construct and produce ecological furniture and other interior objects from the local fibrous plants in Lithuania, real trials starting from the cultivation of raw materials and ending with the production of experimental fibreboards from fibrous plants were conducted during the preparation of the present art project and its theoretical part.

   The testing was performed in the Lithuanian and foreign manufacturing bases. While testing the manufacturing technique of the structural materials from flax/linseed (Linum usitatissimum L.), stinging (fibrous) nettle (Urtica dioica L.) and hemp (Cannabis sativa) on the industrial scale, the following invention was patented: „Fibreboards from fibrous plants and the method of their production "Nr. LT6163, 25 June 2015. During the trials, performed in companies for the sake of the aims presented herein, it was established that, in Lithuania, structural materials from fibrous plants can be processed with the same equipment that is commonly employed for processing wood and its products, and by applying known and operational techniques. The experimental structural materials and structural furniture elements created during the trials were displayed in the exhibitions in Lithuania and Ireland.

   Based on the attention from the press, architects, business people, farmers and other supporters of sustainable development and the invitations to make presentations for various societal groups received, it can be stated that the interest in and the demand for such interior objects is growing in our country. The amount of raw materials has been increasing since the legalization of hemp grown for fibre on 1January 2014. Moreover, there are 1 million ha of land suitable for crop production but still unexploited in Lithuania.

2. Such fibrous plants as flax/linseed (lot. Linum usitatissimum), stinging nettle (lot. Urtica dioica) and hemp (lot. Cannabis sativa) grow naturally in Lithuania, are alternative to wood and suitable for the manufacturing of structural materials. The value of these long-fibre plants lies in the fact that they are suitable for the manufacturing of structural elements as their "building" material for two reasons: their high-quality fibre mass can be processed industrially and they have natural adhesive properties, created by cellulose. The strength characteristics of these fibres can be considered a disadvantage, because the crushing to achieve fractions necessary for the material production is very complicated. This process requires special powerful equipment which was non-existent in Lithuania due to a lack of demand, but currently local farmers already have acquired it. On the other hand, this disadvantage of the fibers' processing becomes the main advantage when they are used to produce structural materials. The fibres are strong and contain high levels of cellulose, thus durable materials are obtained without using additional synthetic binders. This raw material is great for the production of composites. As a reinforcing raw material, it can be mixed with any other organic or synthetic agents. It is recommended to combine the structural materials made from fibrous plants as separate components with elements of natural origin, for instance, natural wood or other plant origin materials. In such a case, the utilization does not include the recycling of composite parts, because they are all self-degradable, thus less energy is used and costs decrease.

3. The wet process technology of manufacturing wooden fibreboards is most suitable for the production of ecological sheet structural materials from flax, nettle and hemp. While applying the said technique, fibres are activated and form cellulose nettings while being treated in a watery medium. For high-quality boards, it is necessary to refine the fibres up to a maximum length of 5-7 mm. Finer fibre is more easily spread, and thus a more even fibreboard surface is formed.

   If the biomass is not purposefully pressed by applying additional force and the water can drain out by itself, low density (light) material of solid form, which breaks easily while being broken, but is not generally frail and maintains the form that has been given to it well, is formed. This material can be used for the production of lampshades or decorative interior objects. Polymeric bioplastics manufactured from the oils of fibrous plants are suitable for the production of compositional eco-materials. The parts of plants that fall off during processing might be used more effectively if such natural binders are applied. These compositional materials acquire features characteristic to plastic and become a low-density, light material, easily

formed in high temperature and maintaining the given form in a natural state, more easily fracturing when mechanically affected by a force higher than the one intended for its exploitation, but recycled without any harm to the environment. This compositional material can be used for the production of plastic furniture analogues. They can be homogenous, and they are easily transported and stored. An ecological object must be composed of one origin materials, its structure must be easily manufactured and, preferably, homogenous.

In order to produce sheet and configured structural materials from fibrous plants, the suitable crushing of the raw material becomes of the most importance. The quality of the adhesion processes, which emerge naturally in the later preparation stages, depends on the latter. In a watery medium, the fibres of flax, nettle and hemp can be reduced to smaller units only by using size reduction equipment with knives operating in a chopping manner. The fibres (of hemp especially) twine round the impellers of rotating devices and stop, bend or break them. Products from fibrous plant biomass maintain the forms obtained while pressing in their hot state and natural state (after cooling) both. Curved elements formed from flax, nettle and hemp biomass are suitable for the same purpose as the curved elements produced from wooden fibreboards.

4. The combination of natural and artificially created colours presents the feeling of the technological and aesthetical applicability of eco-objects in modern spaces. Designers choose their colours and structures carefully and try to secure the balance of the "eco-message" being conveyed. Usually a natural and open exposure of the object's texture prevails and the latter helps the creator to strengthen the aforementioned didactic mission and performs an educational function – demonstrates the structural material, comprehended not only through seeing but through touching also.

   Sustainable development ideas are propagated, the philosophy of the "ecological perspective" is proliferating in the society, but the majority of ecological designers direct their work towards Thrash design, which contributes to the solution of ecological problems only partly.

5. Interior eco-objects of various configurations can be produced from plant fibreboard, because it is sufficiently plastic. This is a sheet, 3.2 – 3.5 mm thick material, thus the structures of objects are often multi-layered: the structural components are connected at their planes to stiffen the element being formed, or connected across so that the components would hold each other and all the structure at the same time. The constructed object can be formed out of several, usually curved, segments, by connecting them at the indentations through an additional fitting. Curved components are very often used to produce objects from sheet materials, because a curved thin structural component is more resistant to the applied force than an even one. A very important and positively viewed factor of constructing ecological design objects is the formation of the connection nodes of the components without additional fitting. The production, transportation, recycling and utilization of fitting also require resources. However, the construction of volumetric eco- objects from the plant biomass is completely different. Such a formation requires dyes in which the objects of a particular shape are formed by hot-pressing. The resulting form can possess spaces for the attachment of other components (by thrusting or pasting). This equipment is also used for the formation of homogenous objects. What is more, the forms prepared can be used to form objects by applying the cold method, also. In such a case, additional binding agents must be used. Other necessary components can be integrated into this self-solidifying mass in advance, thus it also becomes a process of component attachment.

6. There are still no Lithuanian companies working with structural materials from the fibrous plant biomass. In addition, no companies manufacture plant fibreboards. Wood processing traditions are very deeply rooted in our country, there are enough raw materials, and thus the companies thrive from manufacturing standardized production. However, in order to fully realize the ideas of ecological design in Lithuania, only one possibility is lacking: to make configured volumetric eco-objects from plant biomass, because there is no equipment for this purpose, and no ecological alternatives for synthetic resins such as bioplastics, made from plant oils, water-based binders, etc, exist.

   Positive test results and examples of analogues demonstrate that the production of ecologic plant-origin biomaterials and their adaptation for interior Eco objects is possible, although the development and adaptation in the field still remains quite broad.

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