# Scientific report for the 1. period

## PART 1 – INFORMATION ON PROGRAM

1.1. Title of the programme: **"Forest and earth entrails resources: research and sustainable utilization – new products and technologies"**
1.2. Programme acronim: ResProd
1.3. Programme web page address: http://www.kki.lv/index.php?id=238
1.4. Programme principal investigator (PI): Bruno Andersons, +371 552554;
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1.6. Report for a period from 01/10/2014 till 30/06/2015

1.7. The aim of the programme and objectives

The Programme's aim is to provide the sustainability of forestry and the utilization of mineral resources, and to rationally use Latvia's local resources for producing competitive products for the global market, at the same time maintaining sustainability, biological diversity and the social role of forests in the near future and for future generations.
The tasks of the studies include a broad range of issues – from the sustainable cultivation of forests to the economically and ecologically motivated use of resources for competitive materials and products, needed for the national economy and society, in the whole field's value added chain – from the study of the properties and availability of useful mineral resources to novel technologies and competitive innovative products that would substitute the import.

In the Programme's implementation stage 1, the results described in p.1.8., are achieved.

1.8. Executive summary of the programme
*(max. two A4 pages. Summary of scientific results achieved during reporting period, their scientific and applicational significance)*

The Programme is formed by 4 projects, in which the following main results are gained.

Project No. 1. **Even-age spruce stands cultivation potential in fertile forest ecosystems**.

The even-age spruce stands' increased risk group is investigated to elucidate its development tendencies within 10 years. It is hypothesized that, with decreasing growing potential, a radical change in the even-age spruce forest cultivation regulations is required in Latvia. In the thinning sites established in the previous 10 years in the sampling plots, data on the effect of thinning in the initially dense spruce stands are gathered and summarized.

The effect of genetic factors on forest stands' growing and vitality for developing an even-age spruce forest model in fertile forest ecosystems is investigated to perform a more precise selection of genotypes and modify the stands' management regime, diversifying the forest management risks and increasing the incomes. The scientific literature on the effect of the genotype-environment interaction is analysed. The sampling plots' arrangement and survey are carried out, increment borings are gathered for the further analyses.

Data are gathered for comparing the provenance of root and butt rot fungus in even-age spruce stands in peat and mineral soils. The provenance of genetically different mycelia is analysed to forecast the fungi infection propagation and recommend the most suitable method for its restriction. In 3 sampling plots, the propagation assessment of the of root rot *Heterobasidion annosum* s l. genotype is initiated; *H. annosum* isolates and mycelium pure culture are obtained.

A methodology for plantation arrangement is developed, all preparing works are performed, and the planned experimental plantation is arranged. During the further project's implementation, the plantation monitoring, initial measurements and tending are planned.

Project No. 2. **Studies in the field of wood processing, timber logistics and planning**.

A study on novel technological solutions for wood load-bearing and non-bearing building structures and their service properties, a study of the cellular wood material's properties, determining the water vapour transmission characteristics and analysing the condensation risk, was initiated. The efficiency of different fire retardants under varying heat load is investigated. To enhance the energy efficiency of the production, pilot studies of the non-traditional gluing of wood are carried out. The express method for forecasting the chips' ash content is developed.

The decline in the economic value of the round-timber of the most economically significant Latvia's tree species (pine, spruce, birch, aspen), depending on the progression of damages at the time of storage, is investigated. The situation analysis and methodology are prepared. The results will enable foresters and harvesters to plan more precisely the harvesting process and logistics, and to avoid the decline in the round-timber's quality.

The mobilization potentialities of the local wood resources are assessed for sustainable and seasonally even providing of woodworking enterprises with round-timber. Studies on the efficiency of the solutions for wood products' logistics are analyzed. The Sweden's model is acknowledged as the most efficient one in terms of saving time and fuel in the joint timber products' supply chain.

Project No. 3. **Biomaterials and bioproducts from forest resources with versatile applicability**.

***To study the wood materials' competitiveness enhancement potentialities in construction, improving the wood durability properties with coatings and modification methods.***

A method for combined hardwood hydrothermal modification (HTM)/ densification to enhance the strength properties of modified wood is approbated, and optimal pressing parameters are found. Pine HTM with improved biodurability as an alternative for impregnation with biocides is investigated. Studies on the use of HTM birch and pine wood wastes in wood polymer composites are started. Coatings for maintenance modified wood's decorative properties are under development.

Rape seed oil base coatings for enhancing wood's fire-resistance are under development. Optimal synthesis parameters are found for obtaining epoxidized oils; their phosphorylation kinetics is investigated, and the phosphorylated product's obtaining methodology is found. From the synthesized polyols, polyurethane coatings are obtained, and their testing is started.

For obtaining polymer compositions, a method for the mechanical-chemical modification, combining in one process the lignocellulose matrix' activation and functionalization, is studied. To enhance the samples' thermo-stability, the use of aluminium salts is investigated. The further study envisages the formation of composites.

***To evaluate the hardwood wasteless utilization for obtaining products necessary for the Latvian economy, applying advanced chemical and thermal pre-treatment methods and modern research equipment.***

The effect of the thermocatalytic synthesis conditions on the formation and properties of microporous wood carbon materials is investigated. Potentialities of regulating the total pore volume, and micro- and mesopore ratio are elucidated. The most suitable activation regime for obtaining active carbons in supercapacitors is found. To predict the formation of a double electric layer, a correlation between the carbons' physical values and the surface oxygen amount is searched for.

The use of the steam explosion (SE) pre-treatment mass for obtaining heat-insulating samples from grey alder chips and veneer rags is tested. The effect of the SE regimes, raw materials' type, moisture and fraction on the fibering degree is investigated to obtain a material with a low bulk density. Three materials with competitive indices are obtained for further studies. The effect of SE pre-treatment on biomass as an additive in electrospinned polymer nanofibres is investigated, preparing of polymer solutions and suspensions of different composition is envisaged.

For obtaining pyrolytic sugars, studies on spruce and birch wood chips hydrothermal pre-treatment in the temperature range of 150-210$^{o}$C are carried out. With the growth of the treatment temperature, the yield of pyrolytic sugars, mainly levoglucosan, grows. However, the yield of pyrolytic sugars is moderate; therefore, the catalytic activation of lignocellulose with the aim of enhancing the yield up to 30-50% from the cellulose content will be performed.

***To search for solutions for the complex development of products from bark and wood components with properties, comparable with or better than those of synthetic or industrial analogues, and a broad application range in the national economy fields, accelerating and economically perfecting the technological processes***.

For obtaining a biopolymer film, four nanoparticle obtaining methods are tested and compared. A new oxidation pre-treatment method with sodium peroxide is developed; birch and black alder and cellulose nanoparticles are obtained by the original thermocatalytic method. Chitosan-bark nanoparticle films are obtained, and their properties are determined. Bark nanoparticles in the chitosan matrix improved its biological properties.

A study of the effectiveness of microwave pre-treatment for obtaining high-value products of wood and bark extraction is carried out. A microwave extractor design is developed. Treating the samples with microwaves, a higher content of polyphenol compounds is obtained in extraction. Optimal temperatures for obtaining pinosilvin compounds are determined; the application potentialities of microwave activation energy to improve the alder bark extraction with ion liquid are determined.

Project No. 4. **Research into the entrails of the Earth - novel products and technologies** (EARTH)

***Studies on Latvia's resources of the entrails of the Earth (mainly clay, dolomite, peat and sapropel) and launch the experimental and analytical part of the studies.***

Non-traditional resources (flint, ochre, amber, precious stones, salt, etc.) are investigated and evaluated, and monograph studies are prepared. Clay deposits are determined for their further studies for developing novel technologies to produce high-value marketable products.

The feasibility of applying an indirect (geophysical) research method in studies of peat deposits is assessed so that, during the implementation of the further project, to elaborate a methodology for the detailed quality studies of roads and embankments.

***Study of the clay properties for use in sun protection creams, for obtaining biodegradable composite materials and novel sorbents.***

It is found that Latvia's illite-containing clays are able to absorb UV-radiation and to improve the emulsion oil-water stability; therefore, it is possible to use them, for example, in sun protection creams. The development of a method for obtaining finer clay fractions and the study of the emulsion oil-water stability are envisaged. Data on the illite clays' properties, required for their use in biodegradable composite materials for dumps, are investigated.

A method for preparing a granular hollow sphere sorbent is developed. Sorbents' mechanical properties are determined, and their structure and surface morphology are investigated. The material's porosity and sorption properties, depending on the obtained parameters, will be investigated, so that they could be used in agriculture and ecological products.

***Prospective mineral raw materials for finishing and ceramic products.***

The structure of the "clay" mineral – illite is "deformed" by chemical, thermal and mechanical treatment methods, so that to develop a ceramic material with lower firing temperatures, and also to obtain new phases for potential use in novel binders. Practically significant is the observed considerable decrease of the firing temperature, obtaining ceramic materials with the corresponding compressive strength. From clays with high carbonate content, a product with a sufficiently high strength is obtained, which is hardened already at 100°C. The products' investigation will be continued.

Porous cordierite ceramics are developed from mixtures of Latvia's clays, quartz sand and synthetic additives. This ceramics is formed at temperatures that are lower by 200°C, compared with the case of traditional ones, and which is suitable, for example, for purifying hot exhaust gases.

Iillites from Apriķi clay are active for ceramic products' sintering and favouring the new fire-resistant crystalline phases' (for example, corundum) formation process. Compositions of illite with $Al(OH)_3$ form a new dense ceramic material, which, after annealing, can be used as durable flooring, for execution of different building structures, including load-bearing ones. The feasibility of using fine nanoparticle ceramic paint powder will be investigated. The positive effect of illite on the lowering of the mullite–$ZrO_2$ ceramics sintering temperature is shown.

It has been found that Jēkabpils dolomite siftings recycling in new materials is problematic. Also, the obtaining of synthetic gypsum is not realizable because of the use of concentrated sulphuric acid.

***High-porous ceramic materials and analysis of sorption processes.***

High-porous ceramic materials are obtained from clay and oxide raw materials. They possess the ability to absorb different water-polluting inorganic and organic substances depending on: a) the raw materials' mineralogical and granulometric composition; b) firing conditions; c) additional treatment of the ceramic surface; d) specific surface. The materials can be used also as ceramic filters. The further research directions: use of new pore forming additives; nanodisperse coatings to ensure the material's photocatalytic activity; for irradiation with accelerated electrons.

***The study of the metal ions sorption ability of peat and peat active carbon.***

The ability of peat to absorb metals in the context of environment pollution, as well as well with metals' geochemical accumulation in the natural environment, is investigated. The sorption processes' thermodynamics and kinetics are characterized; the effect of the hindering factors on the use of peat as a biosorbent is testified. Different sorption peculiarities of the different valence metal ions are investigated, the sorption regularities are described. Attempts are made to obtain peat in a granulated form, improving the hydrodynamic properties.

The properties of sapropel from Latvia's lakes depending on the sediment formation conditions are studied; the relationship between the peat sapropel formation conditions / sorption capacity is evaluated.

A low type peat substrate composition is developed for biological agriculture in compliance with EU requirements; the attractions and fields of its use are verified.

***Microorganisms' consortia for soil bioremediation; to immobilize and investigate the active components of microbiological fertilizing agents.***

The aim is to immobilize, as biological fertilizer agents, the nodule bacteria *Rhizobium leguminosarum*, used for plant cultivation, and to determine their viability in liquid and different carrier materials. The best results are obtained, keeping the bacteria in suspension or, after immobilization, on peat. The viability of *R. leguminosarum* is retained at a sufficiently high level for a long time, so that it could be used as a biological fertilizer for papilinaceous plants. Laboratory experiments are carried out in semi-sterile conditions; then, the effectiveness of the biopreparations will be tested in field conditions.

In experiments with synthetic wastewater, the suitability of ceramic pellets for immobilizing nitrogen and phosphorus compounds degrading microorganisms for wastewater purification, as well as the further use of pellets for alternative fertilizers, is evaluated. In the vegetation experiment, it is demonstrated that the addition of pellets to sandy loam promotes the tested plants' growth. In the further studies, the flow diagram of wastewater treatment column cascade will be optimized.

1.9. Results of the programme *

| Performance indicator | Results | |
|---|---|---|
| | Planned | Achieved |
| **Scientific performance indicators** | | |
| 1. Scientific publications: | | |
| number of original scientific articles (*SCOPUS*)(SNIP>1) | 56 | 7 |
| number of original scientific articles in journals of the database *ERIH (A and B)* or in proceedings of conferences | 63 | 2 |
| number of reviewed scientific monographs | 6 | 5 |
| 2. In the framework of the programme: | | |
| number of defended doctoral thesis | 26 | 4 |
| number of defended master's thesis | 37 | 4 |
| **Performance indicators of the promotion of the programme** | | |
| 1. Interactive events to promote the process and results of the programme. Target groups should include students and the number of: | | |
| conferences | 94 | 22 |
| seminars | 27 | 1 |
| organized seminars | 3 | - |
| popular-science publications | 26 | 2 |
| exhibitions | 4 | 2 |
| 2. www.kki.lv/index.php?id=238 | | |
| **Economic performance indicators** | | |
| 1. Amount of private funding attracted to the scientific institution in the framework of the programme, including: | 102000 | 40000 |
| 1.1. co-funding from the private sector to | - | - |

| | | |
|---|---|---|
| implement the projects of the programme | | |
| 1.2. income from commercializing the intellectual property created in the framework of the programme (alienation of industrial property rights, licensing, conferring exclusive rights or rights to use on a fee) | - | - |
| 1.3. income from contractual jobs that are based on results and experience acquired in the framework of the programme | 102000 | 26100 |
| 2. Number of applied for, registered, and valid patents or plant varieties in the framework of the programme: | 14 | 1 |
| in the territory of Latvia | 10 | 1 |
| abroad | 4 | - |
| 3. Number of new technologies, methods, prototypes or services that have been elaborated in the framework of the programme and approbated in enterprises | 24 | - |
| 4. Number of new technologies, methods, prototypes, products or services that have been submitted for implementation (signed contracts on transfer of intellectual property) | 6 | 1 |

In case of deviation from planned justification of deviation and planned activities to mitigate deviation.

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| No in this stage. |

1.10. List of results of the programme
(*List of publications, conference thesis, etc.)*

See after every poject.

Leader of the programme _____ 2015
*(Bruno Andersons)* *(date)*

## PART 2: PROGRAMME PROJECT INFORMATION

**2.1. Project No. 1**

| | | | |
|---|---|---|---|
| Title | **Even-age spruce stands cultivation potential in fertile forest ecosystems** | | |
| Project leader's name, surname | Jurģis Jansons | | |
| Degree | Dr.silv. | | |
| Institution | Latvian State Forest Research Institute "Silava" | | |
| Position | director | | |
| Contacts | *Phone number* | | +37126190266 |
| | *E-mail* | | jurgis.jansons@silava.lv |

2.2. Project goal and objectives

*(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)*

**Research of economical, genetical and phytopathological aspects of even-aged spruce stands to develop scientific basis for growth models in fertile forest type and to prepare statements for changes in regulations for this model practical application.**

Repeated assessment of spruce growth potential will provide information on temporal growth and yield development of pure spruce stands, changes in distribution of growth potential groups (collapsing, uncertain, productive) over time and will allow to identify stands with the highest risk depending on stand density, site type and location. Results on growth and yield of pure spruce stands of different initial density and management (thinning) regime and information on assortment structure in these stands will provide input data for further economic analysis of these stands. This information will serve as a basis for recommendations for pure even-aged spruce stand management and provide arguments for possible changes in legislation in order to minimize economic losses in spruce stand management.

Influence of genetics on growth of trees is well known from tree breeding studies and forms basis for selection of best-performing genotypes for propagation (either *via* seed orchards or vegetatively). Results of analysis of progeny trial series demonstrate a notable influence of genotype x environment interaction both on growth and quality traits. This interaction is typically used for delineation of provenance regions and selection of genotypes preforming well in most of the test sites (but not necessarily best in any particular site). In contrast the project activity will focus on collection and analysis of data to assess the potential for selection of site (fine-scale environment) specific genotypes to maximize value-production and stability (resistance) of planted even-age spruce stands and will contribute to development of practical recommendations and legislation to improve the long-term economic return form spruce forests.

Long-term returns from management of spruce forest will be affected also by direct and indirect effects of climatic changes. Therefore adaptation potential determined partly by genetic diversity needs to be preserved in spruce stands, especially if long rotation periods (≥80 years) are used. Project activity will analyse the link between the diversity (determined partly by so far un-known different origins of spruces historically planted in Latvia) and resistance against specific negative environmental factors, contributing to development of practical recommendations for tree breeding and forest regeneration.

On the basis of obtained results it will be possible to compare spread of root and butt rot in even-aged spruce stands on peat soils and on mineral soils. Analysis of territorial spread of genotypes - genetically different mycelium (assessing how many trees are infected in the borders of genotype) will allow to evaluate and to predict the spread of the root and butt rot fungus in the particular stand and also to recommend most suitable silvicultural methods to diminish the spread of root rot.

2.3. Description of gained scientific results
*(Describe scientific results achieved during reporting period, give their scientific importance)*

During the 1st reporting period forest compartment data base to be used in the further growth potential research was compiled, identifying 30-60 years old pure spruce stands that were first surveyed in 2003, 2004 and 2004. Currently 283 out of 355 compartments are identified. Stand structure analysis of these compartments was carried out, 60% of stands are located on dry sites, 23% on drained mineral sites, 14% on drained peat sites and 3% on wet peat sites. 20 stands from the compiled database were surveyed in the field, measurements of representative spruce biogroups (20 trees per stand, DBH, height and basal area measurements, increment cores at breast height) were carried out in line with the methodology developed in 2002 (Zālītis, Lībiete 2005; Lībiete 2008). Increment cores were further processed and analysed in the laboratory of LSFRI Silava.

A second data base was compiled where spruce stands in state forests where thinnings were carried out in 2006 and 2007, as well as control stands without thinnings since 2000 were included. Field survey of potential research objects was carried out and sample plots were established in 10 of the identified stands. Stand structure was measured and tree increment cores taken to be further measured in the laboratory. Radial increment of spruce was measured in the laboratory of LSFRI Silava. Stand structure parameters were calculated from the measured data.

First stage of project was used to review scientific literature on genotype x environment interaction of trees, mainly determined by: 1) climatic (meteorological) conditions; 2) soil fertility (forest type); 3) planting density and thinning regime. It was concluded, that provenance and progeny trials provide sufficient information on influence of climatic conditions. Genotype x forest type interaction might be an important factor determining maximum productivity of stand and there is no sufficient amount of trails to test it in Latvia, however, establishment of such trials is not possible in this project and needs to be addressed separately. Therefore activities of this project will focus on analysis of genotype x soil fertility interaction in trials where fertilization has been carried out and on genotype x spacing interaction in clonal trail with different spacing in order to provide information for most efficient use of selected material with main focus on selection of specific clones for vegetative propagation for plantations with goal to maximize timber (monetary-value) production. This activity was initiated: during first stage of the project four clonal trials were measured and increment cores collected for analysis of growth dynamics.

Literature review was covering also second aspect of the project activity: analysis of genetic diversity and (mathematic and laboratory) methods of its determination. Major factors affecting diversity of seed orchard crop are: 1) number of clones and their relatedness (affective number of clones); 2) differences (asymmetry) of flowering and seed production among clones (i.e. contribution of particular clone to a seed orchard crop). The first aspect has been well studied, but the second is much more difficult to address since it involve different inter-annual variation and interactions (e.g. differences in clone responses to particular precipitation or temperature conditions may impact the development of their male of female strobili or fertility of pollen or selection of pollen during their germination phase etc.). Considering the planed scale of the project activity it was decided to focus on analysis of

actual outcome of all those processes: study of genetic diversity of crop from different seed orchards and years. Additionally analysis molecular markers (Nad and MtD02) will be used to distinguish the origin of potentially introduced Norway spruce stands.

In the territory of Forest Research Station' Kalsnava forest district in three sample plots spread of *Heterobasidion annosum* s.l. genotypes was evaluated to analyse dynamics of spread of fungus in planted even-aged spruce stands. Wood samples were taken from 77 spruces in first sample plot and 44 *H. annosum* isolates were gained. Wood cores from 142 and 112 trees (in second and third sample plot, respectively) were taken using an increment borer. Root and butt rot fungus (pure culture of mycelium) was isolated from 23 spruces in second sample plot and from 9 spruces in third sample plot. All analysed trees were mapped using software *QGIS 2.8.2*. Comparison of genotypes was made in third sample (9 infected trees). As a result five individual genotypes were determined, from which one includes five trees, but other four genotypes were each represented by one tree.

Methodology of plantation installing described in details. Design of experimental field drawn up -where in 3 replicates different species and intervals between seedlings, as well fertilizers will be used :

- spruce (*Picea abies*) with 1000, 2000, 4,000 trees per ha;
- mixed rows one by one spruce with deciduous trees 2000 trees per ha (spruce / birch (*Betula pendula*), spruce / black alder(*Alnus glutinosa*), spruce / poplar (Populus spp.) hash) and only deciduous trees of previously mentioned species;
- spruce / poplar experiment with different initial fertilizer options (wood ash, potassium fertilizer, residues of bio-gas fermentation).

For establishment of experimental – demo object selected initially highly productive, but later withered spruce stand on peat land (*Oxalidosa turf.mel.*) located in Forest Research Station Kalsnava forest region. Sample plots 24m x 60m plots in 3 replications for each variant installed in total area 6.7 ha. Planting of trees was started.

2.4. Further research and practical exploitation of the results

*(Describe further research activities that are planned, describe possibilities to practically exploit results)*

Further stages of the project will focus on measurements of additional Norway spruce clonal trials where both fertilization and different initial spacing has been used and collection of increment cores. Changes of increment and genotype x environment interaction over space (series of trials) and time (analysis of annual rings parameters on calculation of distance-dependent competition indexes) will be carried out.

Further studies will also cover diversity of seed orchard crop from different orchards (in context with different isolation and effective number of clones) and years as well as forest stands (as control material) using a set of different molecular markers. In other activities of the project stands with different resistance and vitality will be determined and genetic material from those stands will be collected to evaluate their origin and genetic diversity.

In further work spread of *Heterobasidion* genotypes in forest stands of different age related to history of forest management will be compared. It is important to determine certain species of fungus causing root and butt rot (*H. parviporum* infects spruce, but *H. annosum* can infect coniferous and deciduous trees) to select the most suitable tree species for forest regeneration in heavily infected sites. In further research it is important to evaluate the occurrence of other fungal species that causes root rot in spruce (mainly *Armillaria*) on peat soils and their impact on productivity and vitality of spruces.

2.5. Dissemination and outreach activities

*(Describe activities that were performed during reporting period to disseminate project results)*

The results of Project I stage are not disseminated due to its specific task – to collect information, choose forest areas and establish research objects for the next periods of Project activities. The presentation of Project's first results is planned in the international scientific conference *''Science based forest sector''*, organised by Latvian forest science institutions and forest commercial sector, held in Riga, 4-6 November, 2015. The forest seminar about Project's activities is planned in the autumn of 2015 or in the spring of 2016 in Forest research station's Kalsnava forest district. The publishing or results in local press is planned since 2016. The results will be prepared for distributing in international pier reviewed issues at 2017.

Leader of the project 1 _____ Jurgis Jansons

## PART 2: PROGRAMME PROJECT INFORMATION

**2.1. Project No. 2.**

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|---|---|
| Title | **Research in sphere of wood processing, logistics and planning of forest products** |

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|---|---|---|---|
| Project leader's name, surname | Dagnis Dubrovskis | | |
| Degree | Dr.silv. | | |
| Institution | Latvia University of Agriculture, Faculty of Forestry | | |
| Position | Dean, professor | | |
| Contacts | *Phone number* | | +371 63021619 |
| | *E-mail* | | dagnis.dubrovskis@llu.lv |

2.2. Project goal and objectives

*(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)*

The goal of 2.1. subproject is to research and develop new technological solutions for improvement of energy efficiency in production of wooden products and biomass, and for the use of wood in construction. The research project is continuous research of previous National research program NatRes (2009-2014). As result of situation analysis found theoretically based solutions for mechanical cutting of wood, established theoretical basis and pilot research in non-traditional wood bonding direction, a method of wood surface energy assessment. Collected technical information about cellular wood material properties and set further research tasks: water vapor transmission; condensation risk analysis in building panels. Researches in direction of reaction to fire next steps are: fire protection efficacy of wood materials under exploitation period; research variable thermal load exposure operational efficiency of the different retardants. Increasing demand for energy wood resources and theoretical knowledge's helps to develop new express method and equipment for prediction quality parameters of wood chips used as bioenergy, for example ash content.

The main of goal of 2.2. subproject is to detect the economic value reduction in high-end round timber (saw logs and veneer logs) made of the economically most important tree species of Latvia (pine, spruce, birch, aspen), depending on the progression of damages at the time of storage. This topic was started in previous State research program, where round wood density changes during storage where determined. In this program we will continue by evaluating timber faults which are appearing during storage. We have gathered information about sustains, drying crooks and insect damage development depending on felling type (harvester or chainsaw), diameter, bark removal, storage place, storage length and meteorological factors. Information about weight reduction and quality change during warm period of the year is obtained. We have prepared methodology for placing timber assortments in the forest to analyze sustain, drying crooks and insect damage evaluation depending on cutting type, diameter, bark removal, storage place, storage lengths and meteorological conditions.

The aim of 2.3. subproject is to evaluate possibilities of local forest resource mobilization for sustainable and seasonally smooth supply of wood processing companies with the raw materials. During the first stage summary from foreign and local research projects about evaluation of different forest product logistic efficiency has been done. During the next stages monitoring of timber primary processing plants will be done and information about their

forest resource consumption volumes, the structure of forest resources used in processing, the assortment of production and the geographical location of the manufacturing units will be gathered.

2.3. Description of gained scientific results
*(Describe scientific results achieved during reporting period, give their scientific importance)*

National research program project N2 "Research in sphere of wood processing, logistics and planning of forest products" continues as research of the previous project NatRes. At the 1st period of this project was prepared analysis of the situation, published publications even as results of previous project, participating in conferences, developed a Master's thesis and research section of doctoral thesis. Since we know better wood, amount of wood as construction material is increasing every year, the research of task 2.1.found theoretically methods and technologies in order to increase the use of wood not only for private use, but also public buildings facade elements. Research results of task 2.2.will benefit knowledge's of civil engineers, architects, builders and specialists of other sectors. Research of the modification of wood and gluing, with the goal of reducing energy and material components, helps producers reduce the production costs, increase the output of wooden products and flow rate. As result of task 2.3. will be developments of useful express methods to determine the raw material quality parameters, such as ash content. Research results will be practically used in LUA master's and doctoral thesis, also results will be able to companies who are producing related wood products.

During first period all literature about our case of analyzes was gathered. When high priced round assortments are stored few days too long it can gain significant influence to the price of one m3 because of quality reduction (sustain, drying crooks and insect damage), that's why first of all it was very important to understand what other scientists have been writing on this topic, to analyze this information and to understand how to relate this information with one we get in previous years. So we evaluated round timber (saw logs, veneer logs) damages which could appear during storage – that was our first task. Second was to make economical evaluations on quality changes during storage. In this part we analyzed information from previous years about weight reduction which can lead to easier forwarding, less pressure to soil, higher loads on one truck by not exceeding weight limits which gives positive impact to forest owner and in this moment it is important to understand in which time storage should be stopped because of quality changes. These results are for all year around. We have made some estimation on recommended storage length.

The review of foreign and local research projects about evaluation of different forest product logistic efficiency have been done. Comparison of different models and methods of forest product logistics as well as. Research shows that in Latvia significant savings in terms of time and fuel could be done in several round wood loading operation.

2.4. Further research and practical exploitation of the results
*(Describe further research activities that are planned, describe possibilities to practically exploit results)*

The outcomes from research of the 1$^{st}$ period shows following research areas in which research should be done: wood cutting tool wear prediction analysis; Taylor formula constants clarification depending on the cutting and feed speed (cutting speed of 20 and 40 m $s^{-1}$); power consumption changes machining of aspen cellular wood material lamellas. In research field of the wood surface energy further research will be done to establish a developed method. As well research should be done to find out a risk of condensation and vapor permeability of the cellular wood material building blocks and reaction to fire should be investigated of facade elements as cladding elements after running outdoors for some period.

In first period of national research program sub-project "Studies of timber, forest products logistics and planning" is prepared one situation analyzes about first two tasks and also methodology which ready to use. In this research information about dynamics of quality changes depending on storage conditions and length will be obtained. All the results will be ready for forest landlords and logging companies, who by knowing the limits of influencing factors will be able to plan more efficient logging process by avoiding or minimizing the round wood quality changes. There will be practical use also in forest logistic and planning. Some parts of this project is included in LLU bachelor, master and PhD thesis. Results will be published in internationally quoted databases and original scientific articles and journals to introduce more public with study progress and results.

During the next stages monitoring of timber primary processing plants will be done and information about their forest resource (round wood, woodchips, pellets, etc.) consumption volumes, the structure of forest resources used in processing, the assortment of production and the geographical location of the manufacturing units will be gathered. Long term availability (volume, assortment, location) of forest resources will be analysed. Information about forest product consumption volumes and location form the one side and geographical availability of forest resources from the other side will be useful for decision makers (ministries, associations, local authorities, etc.) to understand potential forest products harvest, transportation and utilization in certain region.

2.5. Dissemination and outreach activities
*(Describe activities that were performed during reporting period to disseminate project results)*

At the 1st period of the research results published in 9 publications, reported 5 reports at conferences, published a study book, developed 2 master's thesis, and prepared 1 method. Situation analysis showed further research tasks for the 2nd period.

**Publications**


1. Ābele A. Relationship between mechanical and electric cutting power at longitudinal sawing. Research for Rural Development 2014: annual 20th international scientific conference proceedings, LLU, Jelgava, 2014. In: Vol.2, 115-121. (SCOPUS, Web of Science), available: http://www2.llu.lv/research_conf/Proceedings/20th_volume2.pdf
2. Ābele A. Cutting power and capacity of timber cutting to length. Books of thesis of Scientific Practical Conference "Science and practice of development of the Forest sector" / LLMZA, LUA, Jelgava, 2014, 72-75.
3. Freivalde L., Kukle S., Andžs M. Bukšāns E., Grāvītis J. Hemp raw insulation materiāls flammability**.** 4th international Conference's on Innovative natural fibre composites for industrial applications, Composites Part B: Engineering, Volume 67, Rome, 2014, 510–514. (SCOPUS, ScienceDirect), available: http://www.sciencedirect.com/science/article/pii/S1359836814003187
4. Ješauskis E., Iejavs J. Impact of geometric dimensions to the cellular wood material mechanical properties. Books of thesis of Scientific Practical Conference "Science and practice of development of the Forest sector" / LLMZA, LUA, Jelgava, 2014, 85-90.
5. Laiveniece L., Morozovs A. Penetration depth of adhesive depending on applied pressure during gluing process. Journal of International Scientific Publication: Materials, Methods & Technologies. Vol.8, 2014, 84-89, available: http://www.scientific-publications.net/get/1000002/1401698645442443.pdf
6. Laiveniece L., Morozovs A. Penetration depth of polyurethane glues into Norway spruce (*Picea abies* L. Karst.) and Scots pine. Books of thesis of Scientific Practical Conference

"Science and practice of development of the Forest sector" / LLMZA, LUA, Jelgava, 2014, 80-84.

7. Laiveniece L., Morozovs A. Penetration depth of adhesive depending on wood anatomical structure. 13th International scientific conference "Engineering for rural development" proceedings, LUA, Jelgava, 2014. Vol.13,.204-209, (SCOPUS, Web of Science), available: http://tf.llu.lv/conference/proceedings2014/Papers/35_Laiveniece_L.pdf
8. Morozovs A., Bukšāns E., Spulle U. Wood protection by modifying the chemistry.Books of thesis of Scientific Practical Conference "Science and practice of development of the Forest sector" / LLMZA, LUA, Jelgava, 2014, 76-80.
9. Morozovs A., Spulle U., Bukšāns E., Basic concepts of decay resistance mechanisms imparted to wood by modification. In Proceedings of The seventh European Conference on wood Modification ECWM7, Portugal, 2014, 155.

**Books**

Tuherm H., Ābele A. Wood cutting processes, BALTI group, Rīga, 2014, 91 pp.

**Conferences**

1. Andis Ābele. Relationship between mechanical and electric cutting power at longitudinal sawing. Research for Rural Development 2014, May 20-21, 2014, Jelgava, Latvia.
2. Māris Daugavietis, Kaspars Spalvis. The development of technology for obtaining essential oils from Scots pine tree foliage. XXVIII International Scientific Conference WULS Faculty of wood Technology. Wood – Material of the XXIst century. Rogow. November 18-19, 2014, Poland.
3. Laura Laiveniece, Andris Morozovs. Penetration depth of Polyurethane glues depending on wood species. Research for Rural Development 2014, May 20-21, 2014, Jelgava, Latvia.
4. Laura Laiveniece, Andris Morozovs. Penetration depth of adhesive depending on wood anatomical structure. 13th International Scientific Conference Engineering for Rural Development, May 29-30, 2014, Jelgava, Latvia.
5. Laura Laiveniece, Andris Morozovs. Penetration depth of adhesive depending on applied pressure during gluing process. International Conference Materials, Methods and Technologies, June 11-15, 2014, Elenite Holiday Village, Bulgaria.

**Master thesis**

Andis Majors "I profile beams plywood wall connecting constructive solutions".
Lauris Brūvers "Particle pallet blocks physical - mechanical properties depending of technological operating parameters".

**Methods**

Wood surfaces with open tracheid free energy assessment methodology.

Leader of the project 2 _____ Dagnis Dubrovskis

## PART 2: PROGRAMME PROJECT INFORMATION

**2.1. Project No. 3**

| | | | |
|---|---|---|---|
| Title | **Biomaterials and products from forest resources with versatile applicability** | | |
| Project leader's name, surname | Aivars Zurins | | |
| Degree | Dr.sc.ing. | | |
| Institution | Latvian State Institute of Wood Chemistry | | |
| Position | Leading researcher | | |
| Contacts | *Phone number* | | +37129262642 |
| | *E-mail* | | aivarsz@edi.lv |

2.2. Project goal and objectives

*(Describe the project goals and objectives so that the achevements reported below could be placed in context and evaluated)*

The project's general aim is the sustainable and rational use of natural resources, increasing their added value, rational ensuring of Latvia's forestry resources' sustainability and applicability for producing products, competitive in the global market, developing new technologies for wood processing with the minimised effect of the production process on the environment and as much as possible more complete use or utilisation of the production by-products, supplying the necessary energy for ensuring the technological processes. The project's definite aims are to promote the enhancement of the **wood materials' competitiveness in building, to improve the wasteless use of hardwood** and **to offer solutions for the complex development of products from bark and from wood components.**

The project's main tasks and its following activities are:

1) to investigate the wood materials' competitiveness enhancement potentialities in building, upgrading the wood sustainability properties by coatings and modification methods:

- Upgrading of the developed new methods to improve the durability properties of wood by combined thermal modification and densification methods so that to improve its strength;
- Optimisation of the coating compositions for hydrothermally modified hardwood, depending on the application class, also development of a coating for retaining the decorative properties of hydrothermally modified wood;
- Polyurethane coatings with decreased flammability have been developed on the basis of phosphorus-containing polyols, synthesised on the basis of renewable raw materials, for wood protection;

2) to assess the hardwood wasteless applicability for obtaining products, needed for Latvia's national economy, using advanced chemical and thermal pre-treatment methods and research appliances:

- A study of the obtaining possibilities of multifunctional carbon materials from wood, and for test application for gas sorption and in new generation supercapacitors will be carried out;
- Preliminary studies of wood hydrothermal treatment so that to isolate hemicelluloses and to change the matrix for the further processing, obtaining niche chemical compounds, as well as that of the carbonisation process, including the studies of the

process at elevated temperatures and pressure in a liquid (water) medium, are carried out;

- After steam explosion pre-treatment, new heat-insulating and electrospinning materials from lignocellulose fibre micro- and nanotextile materials are obtained for use in smart composite materials and biomedical coatings;
- The torrefied wood production process is investigated, and the first choice of the potential technological regimes and optimal process parameters is carried out.

3) to look for solutions for products' complex development from bark and from wood components with properties, compatible with those of synthetic or industrial analogues, and a wide application range in different fields of the national economy, accelerating and economically upgrading the technological processes:

- A new method for obtaining nanoparticles from modified bark will be developed, and a study of the mechanism of its effect relative to the strength and barrier properties of the commercially usable fibre material (paper, cardboard) will be carried out;
- A study of the efficiency of microwave pre-treatment and development of a liquid extraction method for cascade obtaining of products from hardwood bark in the biorefinery process, as well as the conversion of the extraction residue into a fuel material will be carried out.

2.3. Description of gained scientific results

*(Describe scientific results achieved during reporting period, give their scientific importance)*

**Task 1. Activity 1** A method for combined modification/ densification of deciduous wood is approbated. It has been found that hydrothermal modification (HTM) of deciduous wood at 160-180$^{o}$C decreases the strength properties of wood, because its bending strength and hardness for aspen, alder and birch wood, modifying at 170$^{o}$C, decrease by 20-30% and 35%, but, modifying at 180$^{o}$C - by 45-50%, compared with the case of non-modified wood. In laboratory pressing equipment, the wood densification method was tested to improve the properties of modified wood Densification experiments were carried out at 160$^{o}$C/3 h and 170$^{o}$C/1 h with modified aspen, alder and birch wood. It has been found that the best results (considerably lower "spring-back" effect after holding in water) are for pressing modified wood, compared with non-modified wood. Optimal pressing parameters for producing a quality material have been found: pressing time, temperature, pressure and dynamics of its rise. The increase of density for samples with sizes of 300x100 mm reaches 55-60%. At the same time, a considerable bulk swelling in water was observed, namely, ~12%, ~16% and ~25% for birch, aspen and alder, respectively. In turn, the enhancement of bending strength for birch and alder reached ~ 60%, and that for aspen even up to 70%, compared with the untreated wood. It has been found that, to ensure the biological durability of deciduous wood against rot fungi, hydrothermal modification (HTM) at 160-180$^{o}$C is required.

**Activity 2.** Optimal HTM parameters of pine wood boards at the following regimes ($^{o}$C/h): 160/3; 170/1; 170/3; 180/1 were studied (modification at the regime 180/3 is still envisaged). The regimes are chosen so that to reach, as much as possible, higher biodurability against rot fungi, which, as demonstrated by the results, was not achieved by the 160$^{o}$C/1 h regime. To compare the durability of hydrothermally modified and impregnated wood, samples with sizes conforming to the standard were produced. For comparison purposes, a copper-containing preparation widely used in industrial impregnation was chosen. The required working solution's concentrations for introducing the chosen impregnation agent in wood were determined experimentally, and samples' impregnation was started. For pine, modified at the regimes 160/3 and 170/1, mass losses in HTM treatment were determined (<1% at 160/1, 4.2% at 160/3 and 7.5% at 170/1), wood colour changes were determined, and chemical

compounds' analysis in condensates was performed. Component composition for pine wood after HTM at the 160/3 and 170/1 regimes was determined. In comparison with the case of modified and impregnated wood, wetting angle for HTM pine is 1.5-2-fold higher; respectively, the surface is more hydrophobic. At present, samples for modified wood hardness, equilibrium moisture and other tests are being conditioned. Studies on the use of HTM birch and pine wood wastes in polymer compositions are started. The compositions' mixing was carried out on rolls; in pressure moulding, samples for tests were produced, and their properties (melting index, hardness and water absorption properties, etc.) were determined. It has been found that iron salts-containing compositions protect comparatively well the modified wood from colour changes under the effect of UV. The development of the composition to decrease the water leaching of iron compositions (ageing tests in chamber and outdoor conditions) will be continued. Water-based coating compositions with improved absorption depth for thermally modified wood are developed. For this purpose, compositions with different surface active substances are investigated. For prediction of HTM wood biodurability in outdoor conditions, the so-called double-layer test (samples' sizes 500 x 50 x 25 mm) for wood bio-durability prediction in outdoor conditions was performed. Test duration - 5 years, but biological overgrowing is assessed once per year, and wood fungi are identified. The overgrowing, together with the test site climatic conditions, will enable the evaluation of the wood durability climate index in the corresponding region.

**Activity 3.** The necessary approbation of the rape seed oil chemical analysis and polyol synthesis was carried out. To obtain epoxydised oil with the maximum epoxy number, the following parameters were varied:

- molar ratio between the rape seed oil, acid and hydrogen peroxide;
- acid type – formic acid or ethyl acid;
- catalyst type – sulphuric acid or ion exchange resins;
- catalyst – sulphuric acid concentration;
- hydrogen peroxide concentration.

As a result, synthesis parameters were found, at which epoxyised oil with the maximum epoxy number of 15.6% can be obtained. Then, the phosphorylation kinetics of epoxydised rape seed oil with different amount of phosphoric acid (1, 2, 3 and 5%) was investigated, and the methodology of the phosphorylated product's neutralisation and isolation was worked off. During the work, the obtained polyols' chemical analysis was performed. From the synthesised polyols with different amounts of phosphorus, polyurethane coats were obtained, the coats' testing was started, and mechanical and thermal tests were carried out. An increase in the coke residue was found for the synthesised polyol based coatings, compared with the case of coatings from rape seed oil ethers, carrying out a flammability test. The feasibility of the chosen synthesis method and the synthesised polyol's efficiency for the further studies were approved.

**Activity 4.** The previous lignocellulose matrix modification method had its own drawbacks, connected with the use of a two-stage modification process and the long term of modification. The investigated mechanical-chemical modification method makes it possible to combine the activation and functionalisation of the lignocellulose matrix in one process and to eliminate the existing drawbacks. Planetary ball mills with a power of 1250 W, using zirconium oxide balls, were used for mechanical-chemical modification; grey alder sawdust was used as the raw material. The technological parameters of the mechanic-chemical modification of wood varied in the following range: 1) cutting speed – 100-650 rev/min, 2) treatment time from 15 min to 3 h. 32 modified samples were obtained in the modification process. The results have shown that, depending on the employed modification parameters, the yield of the modified products varied from 62% to 99%. The content of the microparticle fraction < 100 μk in the modified samples varied from 15 to 76 mass %, zeta-potential of its functionalised surface

varied from -17.6 mV to -32.8 mV, but wetting angle decreased from 88$^{o}$ to 79$^{o}$ with increasing nitrogen content from 0.69 mass % to 4.1 mass %. The obtained FTIR spectra and chemical analysis pointed to an essential destruction of the lignocellulose matrix as a result of the mechanic-chemical modification at the amination duration more than 3 h. In parallel, the aminated samples were treated with an aluminium complex salt with the aim to enhance thermostability, taking into account the thermal regime for processing wood-polymer composite materials. The content of Al ions in the obtained samples varied from 0.01 mass % to 0.05%. The aluminium ions determination method was based on their ability to form orange-red complex compounds with aluminium ions. It has been found that the introduction of Al ions in the lignocellulose matrix does not have a pronounced effect on the component composition and acid groups' content in the modified products.

**Task 2, activity 1.** The effect of the thermocatalytic synthesis conditions on the formation and properties of wood based microporous carbon materials was studied. The carbon materials were investigated by nitrogen sorption, roentgen and RAMAN spectrometry methods, SEM, elemental and functional composition analyses. It has been found that the increase in the activation temperature from 600 to 800$^{o}$C causes the enhancement of the mesopore part in the porous structure, which has an adverse effect on the supercondenser cells' capacity.

It has been found that the changes in the activation temperature and the dosing of the alkaline activator can be used not only to control the total pore volume, but also to regulate the micro- and mesopore ratios. The low temperature activation regime has been found to be the most attractive one for the use of active carbon (AC) in supercapacitors with a sulphuric acid based electrolyte. A correlation between the AC porous structure indices and electrochemical properties, depending on the synthesis conditions, was determined. Using a water electrolyte, it has been found that the micropore volume of 0.5 $cm^3/g$ is sufficient for the effective formation of a double electric layer in AC pores. The total amount of the electrolyte in the electrode, which is concentrated in micro-, meso- and macropores in the 1.4 $см^3/g$ volume, is sufficient to ensure the ion transferability. Using sulphuric acid as an electrolyte, the capacity of supercondenser's cells reached more than 300 F/g. To characterise the AC properties, immersion calorimetry was used, which is a powerful instrument for information on the accessibility for the micropore system and nitrogen groups' determination. Using immersion calorimetry (in water and benzene) for AC with different temperature activation (600-750$^{o}$C), a correlation between enthalpy, specific porous surface and surface nitrogen amount was elucidated, which will enable predicting the formation of a double electric layer. It is shown that the activation of wood with KOH is less effective than that with NaOH despite the similar mechanism of action. It has been found that the decisive factor is the fact that charcoal has a different initial porous structure and a functionalised heterogeneous composition.

**Activity 2.** The use of the steam explosion pre-treatment mass for producing heat-insulating samples from grey alder chips and veneer flakes, applying the steam explosion method (SE), was tested. The effect of the regimes, feedstock moisture, and the fraction and material type on the fibering degree was determined, which is expressed as the decrease in density before and after the fibering. When fibering, it is essential to obtain a material with possibly great volume and small bulk density, $\leq$ 60 kg $m^{-3}$, because it is the optimal work density for the insulation materials already existing on the market and would be as a prototype for further research. As a result, three materials were obtained, which meet these demands, and further research will be carried out. The effect of the steam explosion (SE) pre-treatment on biomass as a filler for electrospinned polymer nanofibres was investigated. For obtaining lignocellulose nanofillers, a treatment regime with a severity factor $logR_0$ of 4.45, with the following water and alkali extraction, was chosen. After the SE and extraction, the samples were subjected to the treatment in a ball mill (to prevent agglomerates and decrease the SE

mass fractions sizes), with a treatment time of 10 min. For obtaining spinning solutions/suspension, lignocellulose was subjected to high frequency ultrasound in water medium with the treatment time of 30 min. Further studies are directed to preparing polymer solutions and suspensions, varying for different compositions both the polymer and nanocellulose ratio 0%, 1%, 5%, 10%, 15% and 25% (mass %).

**Activity 3.** Studies on the hydrothermal pre-treatment of spruce and birch wood chips were carried out in a Parr 4554 reactor (V=7.5l) at a temperature of 150-210$^{o}$C. Analysing the hydrothermal treatment results, it has been found that, at temperatures above 150$^{o}$C, extraction of the wood hemicelluloses part occurs, and, with the further elevating of treatment temperature, the lignocellulose yield decreases, which changes little in the temperature range of 190-210$^{o}$C. The analysis of filtrates after the hydrothermal treatment shows that, up to the temperature of 180$^{o}$C, the amount of sugars transferred into solution grows, but then it starts to decrease. Thermogravimetry data testify that, along with the growth in hydrothermal temperature, the energy of wood degradation activation grows dramatically, which is connected with the increase in the cellulose content, for the chemical degradation of which a greater amount of energy is required, compared with the case of the hemicelluloses part. However, at temperatures above 190$^{o}$C the activation energy starts decreasing again, which is explained by the changes in cellulose and its crystalline part, as a result of which the degree of polymerisation of cellulose decreases. The increase in the non-volatile residue, with increasing treatment temperature, in the beginning, is connected with the extraction of the hemicelluloses part, but then the cellulose amorphous part, as a result of which the amount of volatile products decreases essentially, but the carbon formation is enhanced. The aim of the analytical pyrolysis experiments was to gain information about the effect of hydrothermal treatment on the thermal degradation products and the changes depending on the temperature. The results testify that, compared with the case of untreated wood, the amount of $CO_2$ and low-molecular compounds decreases, but the amount of lignin derivatives increases considerably; in its turn, the amount of carbohydrates in the degradation products grows, but begins to drop at treatment temperatures above 190$^{o}$C. However, with the treatment temperature, the yield of pyrolytic sugars, mainly levoglucosan, grows, which, despite the above-mentioned decline in the carbohydrates' amount, grows 4-fold for spruce wood, but 10-fold for birch wood, in comparison with the case of untreated wood.

Pyrolysis at 380-410$^{o}$C in the superheated steam flow has shown that the yield of pyrolytic sugars is moderate, namely, 6-8% from cellulose, which is not sufficient. In the further studies, it is envisaged to perform the catalytic activation of cellulose so that to decrease its degradation temperature and to achieve the pyrolytic sugars' yield of 30-50% from the cellulose content.

The activity 4 was not started in this period because of the insufficient funding.

**Task 3, activity 1.** Employing the original thermocatalytic method, birch and black alder bark and cellulose nanoparticles were obtained, which were used for obtaining biopolymer film with enhanced biological properties. New sodium peroxide oxidation pre-treatment for thermocatalytic nanoparticles' obtaining method is developed.

Four methods for obtaining nanoparticles, namely, thermocatalytic, acid hydrolysis, TEMPO and sodium peroxide oxidation pre-treatment were tested and compared. Chitosan-bark nanoparticle films were obtained, and their properties – mechanical and biological ones – were determined. For the obtained film samples, mechanical strength and antibacterial activity were determined in *in vitro* cell tests. The obtained results have shown that the addition of birch bark nanoparticles demonstrates no statistically significant improvements, compared with the case of the pure chitosan film. The studies on the antimicrobial activity of the tested samples have shown that wood bark nanoparticles can get into the chitosan matrix

so that to improve its biological properties – *in vitro* cells' biocompatibility. The cells' viability was higher on chitosan-bark films, compared with the case of pure chitosan films.

**Activity 2.** A study of the microwave pre-treatment efficiency for obtaining high-value products of its extraction from deciduous tree bark was carried out. The microwave extractor's design for the fractionalisation of different types of biomass and its chemical transformation products was realised based on the corresponding dielectric characteristics in polar solvents and the raw materials' requirements, necessary for the input of the given type of energy. The equipment was fabricated on the basis of a household microwave oven, with a radiation power of 800 W, and consisted of a resonator, a reactor, a control panel, a mixer and a cooler. Without the microwave treatment of softwood, the yield of lipophilic (0.99%, w/w) and hydrophilic extractives (2.39% w/w) with ASE is higher, compared to the case of the microwave treatment up to 10 min – 0.93% and 2.16% w/w, respectively. However, comparing the content of polyphenol compounds, it can be seen that it is higher in the case of the microwave treatment of the sample up to 190ºC – using higher temperatures, its content starts decreasing. Comparison of the content of extracted polyphenol compounds in the softwood samples without the microwave treatment (0.15 GSE g/g extr.) shows that it is higher after the microwave treatment (0.27 GSE g/g extr.). The microwave treatment of pine and spruce mixtures at temperatures above 180 ºC for obtaining pinosilvin compounds is not advisable, because then the decline in those compounds' concentration in the sample and, respectively, also in the extract, occurs. Employing the (Biotage® Initiator) microwave activation energy in the grey alder bark extraction with the ion liquid 1-butyl-3-methylimidazol dimethyl phosphate [BMIM]DMP], it has been found that, increasing the microwave energy from 100°C/h to l50°C/h, it is possible to increase the solubility of grey alder bark therein, compared with the extraction, in which the microwave activation energy is not employed, but the obtained products are not with the expected target properties, as in the case of using the microwave energy 100°C/h. Along with temperature, the yield of alder (grey alder, black alder) bark extraction grows, although the temperature above 90ºC gives only a relatively moderate contribution by ~ 1%, compared with the extraction at 100ºC, and there is a risk of the degradation of the obtained compounds, which is testified by the fact that, at the extraction temperatures above 120ºC, the yield of the ethyl acetate extract grows, but the yield of the ethyl alcohol water extract begins to decrease. The properties of the UV radiation absorption properties of the stilbenoid fraction extracted from lignin and pine are investigated, and a strong protective ability of those polyphenols in alcohol against UV-B-radiation, and for lignin also against the UV-A-radiation, is shown.

2.4. Further research and practical exploitation of the results
*(Describe further research activities that are planned, describe possibilities to practically exploit results)*

The following tasks are envisaged in the project's next stage:

*Task 1.* Study of the optimal HTM treatment parameters for pine wood.
Optimal pigment and UV absorber combinations for retaining the decorative properties of modified deciduous wood, depending on the use class.
Synthesis of phosphorus-containing polyols; fabrication and testing of polyurethane coatings.
Study of the pre-treatment and functionalisation of the grey alder lignocellulose matrix for obtaining a wood-polymer composite material additive.

*Task 2.* Employing immersion calorimetry, a study of the thermal effects of the interaction of biomass and active carbons with different solvents and electrolytes.
Studies of the hydrothermal extraction of wood at temperatures of 160-250ºC.
Research of the wood torrefaction process.

Investigation of the dependence of the bulk density and fractional composition of the raw materials on the particles' distribution and steam explosion conditions. Optimisation of the parameters of the fibres obtained in steam explosion and effect on the polymer composites' properties.

*Task 3.* Perfection of the laboratory microwave reactor, studies on the effect of biomass and its suspensions on wood components.
Obtaining and testing of extracted and non-extracted hardwood oxypropylated bark in polyurethane compositions.
Study of the possibility of obtaining nanoparticles by a modified thermocatalytic method from extracted and non-extracted black alder and birch bark, employing the pre-treatment with oxidation.

2.5. Dissemination and outreach activities
*(Describe activities that were performed during reporting period to disseminate project results)*

*Scientific publications:*
- number of original scientific articles (*SCOPUS*) - 5;
- number of original scientific articles in journals of the database *ERIH (A and B)* - 1;
- in proceedings of conferences - 21;

*In the framework of the programme*:
- number of defended doctoral thesis - 1,
- number of defended master's thesis - 1

*Interactive events to promote the process and results of the programme*:
- participation in the conferences -16;
- popular-science publications - 1;
- participation in the exhibitions – 2;
- popular-science lectures about programme results – 1.

*Participation in submitted Horizont 2020 projects* – 3.
*Income from contractual jobs that are based on results and experience acquired in the framework of the programme* – 6100 EUR (from Nova Pangaea Technologies Ltd, UK).

## 1. Publications

### *1.1. Original scientific articles (SCOPUS)(SNIP>1)*


1. Biziks V., Andersons B., Sansonetti E., Andersone I., Militz H., Grinins J. (2015). One stage thermo-hydro treatment (THT) of hardwoods: an analysis of form stability after five soaking-drying cycles. *Holzforschung*, 69(5): 563-571 (http://www.degruyter.com/view/j/hfsg.2015.69.issue-5/hf-2014-0083/hf-2014-0083.xml;
2. Lundqvist A., Magnusson L.U., Ullström C., Krasilnikova J., Telysheva G., Dizhbite T., Hultén L.M. (2015). Oregonin reduces lipid accumulation and proinflammatory responses in primary human macrophages. *Biochemical and Biophysical Research Communications*, 458(3):693-9 (http://www.sciencedirect.com/science/article/pii/S0006291X15002466;
3. Ponomarenko J., Dizhbite T., Lauberts M., Volperts A., Dobele G., Telysheva G. (2015). Analytical pyrolysis - a tool for revealing of lignin structure-antioxidant activity relationship. *Journal of Analytical and Applied Pyrolysis*, 113:360-369 (http://www.sciencedirect.com/science/article/pii/S0165237015000704;
4. Sutka A., Sutka A., Gaidukov S., Timusk M., Gravitis J., Kukle, S. (2015). Enhanced stability of PVA electrospun fibers in water by adding cellulose nanocrystals.

*Holzforschung*, 69(6):737-743 (http://www.degruyter.com/view/j/hfsg.2015.69.issue-6/hf-2014-0277/hf-2014-0277.xml;

5. Yakushin V., Sevastyanova I., Vilsone D., Kirpluks M. (2015) Properties of polyurethanes based on tall oil esters with intumescent flame retardants. *Materials Science (Medžiagotyra)*, 21(2):226-231. (http://dx.doi.org/10.5755/j01.ms.21.2.5784;

### *1.2. Original scientific articles in journals with ISSN code*

a) published:

1. Volperts A., Dobele G., Ozoliņš J., Mironova-Ulmane N. (2015). Synthesis and application of nanoporous activated carbon in supercapacitors. *Scientific Journal of RTU. Materials Sciences and Applied Chemistry* (31):16-20 (http://dx.doi.org/10.7250/msac.2015.003; Publikation: pub20325.pdf).

b) under publication:

**1.** Meija-Feldmane A. (2015). Leachates of Thermally Modified Pine (Pinus sylvestris L.) wood. *Proceedings of the Latvia University of Agriculture*, 34(329) (Manuscript: Anete MeijaFeldmane170815 ar komentāriem.labots2.docx;

### *1.3. Original scientific articles in proceedings of conferences*

1. Andzs M., Tupciauskas R., Veveris A., Gravitis J. (2015). Impact of wood fraction, moisture and steam explosion on the development of an innovative insulation material. *Environment. Technology. Resources. Proceedings of the 10th International Scientific and Practical Conference. June 18-20, 2015. Rezekne, Latvia, 2015*, Rezekne: Rezeknes Augstskola, 1:11-15 (http://dx.doi.org/10.17770/etr2015vol1.210; oral presentation)

2. Andžs M., Tupčiauskas R., Vēveris A., Aboliņš J., Grāvītis J. (2015). Koksnes frakcijas, mitruma un tvaika sprādziena ietekme uz inovatīva izolācijas materiāla izstrādi. Zinātniski praktiskā konference "Zinātne un prakse nozares attīstībai", Jelgava (Latvija), 2015. gada 16.-19. marts, 2015, (http://www.mf.llu.lv/getfile.php?id=1114 (oral presentation)

3. Arshanitsa A., Telysheva G., Dizhbite T., Akishin Y., Zile E. (2015). The effect of microwave treatment of plant biomass on its composition and structure. *Biorefinery for Food & Fuels & Materials 2015 symposium (BFFM 2015). 15-17 June 2015. Montpellier, France. Abstract book*, :107 (poster)

4. Brovkina J., Shulga G., Neiberte B., Ozolins J., Verovkins A. (2015). Difference in the treatment effectiveness of woodworking wastewater between polyaluminium chloride-based coagulants. *Environment. Technology. Resources. Proceedings of the 10th International Scientific and Practical Conference. June 18-20, 2015. Rezekne, Latvia*, 2:64-70 (http://dx.doi.org/10.17770/etr2015vol2.250; (oral presentation)

5. DizhbiteT., Jashina L., Andersone A., Lauberts M., Lauberte L., Telysheva G. (2015). Evaluation of lignin and low molecular phenylpropanoids as a green ingredient of cosmetic sunscreens. *9th World Congress on Polyphenols Applications, June 3-5, 2015, St. Julian's, Malta*, :90 (poster)

6. Gravitis, J., Šutka A., Kukle S. (2015). Steam exploded hemp nano-cellulose and –lignin influence on poly(vinyl alcohol) electrospun nanofibers structure and properties. *The 7th EuroNanoForum 2015, 10-12 June 2015, Riga, Latvia, 2015*, 1.

(http://euronanoforum2015.eu/wp-content/uploads/2015/03/Abstract_Gravitis.pdf; (poster)

7. Yakushin V., Sevastyanova I., Vilsone D., Avots A. (2015). Effect of phosphorus-containing reactive flame retardants on the properties of bio-based polyurethane coatings. *Management Committee Meeting, Working Group meeting "Bio-based Building Products and Fire Safe Design of Buildings - Recent developments", 20th – 21st April 2015, Barcelona, Spain. Book of abstracts (COST Action FP1404)*: 57-58 (http://www.costfp1404.com/en/Documents/N076-05_Book%20of%20abstracts%20meeting%20in%20BCN.pdf; (oral presentation)
8. Lauberts M., Lauberte L., Dizhbite T., Kazernaviciute R., Venskutonisand P. R., Telysheva G. (2015). Evaluation of oxidative resistance of mayonnaise enriched with alder bark extract. *10th Baltic Conference on Food Science and Technology "Future Food: Innovations, Science and Technology", FoodBalt – 2015, Abstract Book, May 21-22, 2015 Kaunas, Lithuania*, :72 (poster)
9. Meile K., Zhurinsh A. (2015). Aspects of the incorporating the production of the levoglucosan into a wood-based biorefinery. *International Conference of Young Scientists on Energy Issues CYSENI 2015, May 27-28, Kaunas, Lithuania*, abstrakts 1 p. (http://www.cyseni.com/files/Past%20Conference/2015/CYSENI_2015_abstracts.rar, (oral presentation)
10. Meile K., Zhurinsh A. (2014). Separation of 1,6-anhydro-β-D-glucopyranose and1,6-anhydro-β-D-glucofuranose. *19th International Scientific Conference "EcoBalt 2014", Riga, Latvia, October 8-10, 2014. Book of abstracts*, :42 *(Mutisks ziņojums, publikācija: EcoBalt_2014.pdf; prezentācija: EcoBalt2014_Meile_VPP.pdf).*
11. Rozenberga L., Vikele L., Treimanis A. (2014). Obtaining methods of nanoparticles from wood residues. *COST FP1205, October 15-16, 2014, Madrid, Spain,* :64 (poster)
12. Shulga G., Neiberte B., Verovkins A., Jaunslavietis J., Vitolina S. (2015). Functionalization of the Wood-Based Filler for Polymer Composite Materials. *Book of Abstracts of the International Conference „Eurofillers Polymer Blends 2015", Montpellier, France, April 26-30, 2015*, 1 p. (poster)
13. Telysheva G., Dizhbite T., Lauberts M., Lauberte L., Vevere L., Arshanitsa A., Janceva S. (2015). The biorefinery based approach to the bark extraction processing *Biorefinery for Food & Fuels & Materials 2015 symposium (BFFM 2015). 15-17 June 2015. Montpellier, France. Abstract book,*:68 (oral presentation)
14. Vecbiskena L., Vikele L., Rozenberga L. (2015). Nanoparticles from wood residues as reinforcement in polymer-matrix composites. *The 7th EuroNanoForum 2015, 10-12 June 2015, Riga, Latvia, 2015*, 1 p. (http://euronanoforum2015.eu/wp-content/uploads/2015/03/Abstract_Vecbiskena.pdf; (poster)
15. Vecbiskena L., Vikele L., Rozenberga L. (2015). Films made of wood residues nanoparticles: mechanical processing and physical properties. – *COST Action FP1205 „Innovative applications of regenerated wood cellulose fibres". Advances in cellulose processing and applications – research goes to industry. Joint Working Groups & Management Committee Meeting. March 10-11, 2015, Iasi, Romania. Program and Book of Abstracts*, : 70 (poster)

16. Vecbiskena L., Vikele L., Rozenberga L. (2015). Designing and evolution of cellulose-based nanofillers-doped chitosan films. - *COST ACTION FP1105, Zurich, Aug 31st – Sep 1st 2015*, 2 p. (oral presentation)

17. Vevere L., Arshanitsa A., Telysheva G. (2015). Oxypropylation of Grey Alder bark and its fractions to obtain polyols usable for production of rigid polyurethane foams. *6th Workshop on Green Chemistry and Nanotechnologies in Polymer Chemistry, 15-17 July 2015, Braganca, Portugal. Workshop ProceedingsPortugal. Workshop Proceedings*, :7-8 (oral presentation)

18. Vikele L., Rozenberga L., Treimanis A., Ormandroyd G.A. (2014). Improved properties of biodegradable paper by adding nanoparticles from wood residues. *COST FP1205, October 15-16, 2014, Madrid, Spain,* :30 (oral presentation)

19. Volperts A., Dobele G., Mironova-Ulmane N., Sildos I., Ozolinsh, J. (2015). Nanoporous wood-waste based carbons for supercapacitors electrodes. *The 7th EuroNanoForum 2015, 10-12 June 2015, Riga, Latvia, 2015*, 1 p. (http://euronanoforum2015.eu/wp-content/uploads/2015/03/Abstract_Volperts.pdf; (poster)

20. Zhurinsh A., Dobele G., Jurkjane V., Meile K., Plavniece A. (2015). Hydrothermal pretreatment impact on the yield and composition of pyrolysis products. *Book of abstracts. FP1306 COST Action (LIGNOVAL) "Valorisation of lignocellulosic biomass side streams for sustainable production of chemicals, materials & fuels using low environmental impact technologies". First Workshop & Second MC Meeting, Belgrade (Serbia) 2015.*, :68 (oral presentation and poster)

**21.** Вольперт А., Добеле Г., Журиньш А., Вервикишко Д., Школьников Е. (2015). Микропористые угли на основе отходов древесины для электродов суперконденсаторов. *International Symposium "Актуальные проблемы теории адсорбции, пористости и адсорбционной селективности", 13-17 апреля 2015 года Москва – Клязьма,* :50 (poster)

### *1.4. Popular-science publications*

**1.** Andersons B. (2015). Do not sit down on the other needle. *Energy and World*. June-july, 3(92):68-72

### *1.5. Patents*

a) saņemti

1. Šuļga G., Brovkina J., Neiberte B., Ozoliņš J., Neilands R. (2015). Koksnes pārstrādes uzņēmumu notekūdeņu attīrīšanas paņēmiens no lignīna un hemicelulozes vielām. *Patenti un preču zīmes. Latvijas Republikas Patentu valdes oficiālais vēstnesi*, 20.02.2015, (2):144. Latvian patent LV 14789 B). (kopija: 20150220.pdf).

b) iesniegti

1. Šuļga G., Neiberte B., Uzulis S., Vitolina S., Šakels V., Jaunslavietis J. (2015). Lignocelulozes pildvielas iegūšanas paņēmiens koksnes-polimēru kompozītmateriāliem. Patent aplication P-15-78, Iesniegts 21.07.2015 (apliecinājums: Patenta_pieteikuma_atbilstiba_2015.pdf).

## 2. Students qualification works

### *2.1. defended doctoral thesis*

Šutka A. (2015). Technologies, structure and properties of lignocellulosic nanofibre bicomponent filaments. Presentation 18/05/2015, Riga Technical University, http://www.lza.lv/index.php?option=com_content&task=view&id=2732&Itemid=461;

***2.2.defended master thesis***

1. Jablonskis A. Magister of natural sciences, chemistry. Latvian University, Faculty of Chemistry, 30.06.2015.

***2.2. defended bachelor thesis***

1. Kivleniece Z. Bachelor's degree in engineering, chemical technology. Riga Technical University, Faculty of Materials Science and Applied Chemistry, 30.06.2015.

**2.** Kuka E. Bachelor's degree in engineering, chemical technology. Riga Technical University, Faculty of Materials Science and Applied Chemistry, 30.06.2015.

**3. Participation in conferences**

1. *Environment. Technology. Resources. Proceedings of the 10th International Scientific and Practical Conference. June 18-20, 2015. Rezekne, Latvia, 2015.*
2. *Zinātniski praktiskā konference "Zinātne un prakse nozares attīstībai", Jelgava (Latvija), 2015. gada 16.-19. marts, 2015.*
3. *Biorefinery for Food & Fuels & Materials 2015 symposium (BFFM 2015). 15-17 June 2015. Montpellier, France.*
4. *9th World Congress on Polyphenols Applications, June 3-5, 2015, St. Julian's, Malta.*
5. *The 7th EuroNanoForum 2015, 10-12 June 2015, Riga, Latvia.*
6. *Management Committee Meeting, Working Group meeting "Bio-based Building Products and Fire Safe Design of Buildings - Recent developments", 20th – 21st April 2015, Barcelona, Spain.*
7. *10th Baltic Conference on Food Science and Technology "Future Food: Innovations, Science and Technology", FoodBalt – 2015*
8. *International Conference of Young Scientists on Energy Issues CYSENI 2015, May 27-28, Kaunas, Lithuania*
9. *19th International Scientific Conference "EcoBalt 2014", Riga, Latvia, October 8-10, 2014.*
10. *The International Conference „Eurofillers Polymer Blends 2015", Montpellier, France, April 26-30, 2015.*
11. *Biorefinery for Food & Fuels & Materials 2015 symposium (BFFM 2015). 15-17 June 2015. Montpellier, France.*
12. *6th Workshop on Green Chemistry and Nanotechnologies in Polymer Chemistry, 15-17 July 2015, Braganca, Portugal.*
13. *FP1306 COST Action (LIGNOVAL) "Valorisation of lignocellulosic biomass side streams for sustainable production of chemicals, materials & fuels using low environmental impact technologies". First Workshop & Second MC Meeting, Belgrade (Serbia)*
14. *International Symposium«"Актуальные проблемы теории адсорбции, пористости и адсорбционной селективности",13-17 апреля 2015 года Москва – Клязьма.*
15. *COST FP1205, Seminar "Ongoring modification of cellulose nanofibres and their potential applications" October 15-16, 2014, Madrid, Spain.*
16. *COST Action FP1205, Meeting "Advances in cellulose processing and applications – research goes to industry, March 10-11, 2015, Iasi, Rumania.*

**8. Participation in the exhibitions**

1. Riga Food 2015, Brokerage Event, 3rd September 2015, Teliševa G., Latvian State Institute of Wood Chemistry https://www.b2match.eu/rigafood2015/participants/8)
2. The International Exposition in Hannover „Hannover Messe 2015", Germany, 13-17 April 2015(in the Latvian national stand, thematical section „Research & Development" (http://www.kki.lv/index.php?id=241).

**9. Submitted Horizont 2020 projects**

1. Partnership for strengthening the excellence of the Latvian State Institute of Wood Chemistry (Proposal acronym: WoodPartners). Horizon 2020 Call: H2020-TWINN-2015; Type of action: CSA; Proposal number: 692136.
2. Wood-based Carbon Catalysts for Low-temperature Fuel Cells. M-ERA.NET Transnational Call.
3. Demonstration project for the thermochemical fractionation of forest biomass (Demo project REFNOVA; Horizon 2020 Call : H2020-BBI-PPP-2014-1 BIO BASED INDUSTRIES).

**10. Interactive events to promote the process and results of the programme**

1. L.Vikele. Popular-science lecture about programme results, "Cellulose – wood component for paper and for producing of innovative nanoparticles", 22nd Congress of Latvian Material Investigation Society, Riga, Latvia, 19/03/2015.

Leader of the project 3 _____ Aivars Zurins

## PART 2: PROGRAMME PROJECT INFORMATION

**2.1. Project No. 4**

| | | | |
|---|---|---|---|
| Title | „Studies of mineral resources- the new products and technologies" (Zeme) [Earth] | | |
| Project leader's name, surname | Valdis Seglins | | |
| Degree | Dr. geol. | | |
| Institution | University of Latvia | | |
| Position | Senior researcher | | |
| Contacts | *Phone number* | | 29265952 |
| | *E-mail* | | Valdis.Seglins@lu.lv |

2.2. Project goal and objectives

*(Describe the project goals and objectives so that the achievements reported below could be placed in context and evaluated)*

*Overall objective for the project the first phase is* to perform the studies of mineral resources (mainly clay, dolostone, peat and gyttja) and initiate experimental and analytical part of the project.

| Project goal and objectives | Major results |
|---|---|
| 1. Study mineral resources and determine mineral deposits suitable for studies in details for the Second Phase of the project. Initiate experimental and analytical part of the project. | Wide range of local mineral resources was studied in details - besides traditional (sand and gravel, clay and dolostone) with particular attention to technological properties, studies include salt, colored stones, flint, ochre and amber. The least was finalised in original per review monographs. For studies in details selected several clay deposits (Kuprava, Nīcgale un Tūja) suitable for development new technologies and products. Strongly developed geophysical research methods (mainly georadar) in peat deposits to reach high resolution geological research applications. Most these studies will be finalised during the 2nd phase of the project. |
| 2. To investigate treatment, preparation and modification possibilities of Latvian clays for development of new technologies and innovative products with high added value for application in cosmetics and improvement of environmental quality (innovative sorbents and biodegradable polymers). Particular objectives of project in the 1st period: Investigation of clay properties for application in sunscreens and development of biodegradable composite materials and | The most stabile emulsions were obtained by the addition of 10 mass% untreated clay fraction with the highest content of clay minerals. The obtained results show that illite clays from Latvia with fraction under 2 μm can be used in cosmetic product like sunscreen as natural UV filter and possibly emulsifier. ochre |

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|---|---|
| innovate granular sorbent | |
| 3. To determine and limit the choice of perspective mineral raw materials to use for development of ceramic products | According to their chemical and phase compositions as well as transformation during thermal treatment, the most promising and usable for the work in the 1st period mineral raw materials was clay from deposits of Laza-Apriki, Nicgale, Prometejs, Kallukalns and Pavari, as well as quartz sand from Bale query and Jekabpils dolomite wastes). They were used to develop: (a)Low temperature (100 – 150 °C) setting 'geopolymer' materials with compressive strength of 15 – 20 MPa, mainly for the use in restoration of buildings and cultural monuments; (b) Porous, cordierite crystalline phase-containing ceramics, using carbonate-containing Nicgale clay and quartz sand from Bale query; cordierite formation temperature of 1200°C (traditionally – 1400 °C); (c) Dense ceramic material with increased strength and varying colour palette by using from clay-separated illite fraction and $Al(OH)_3$ as additive. (d) Mullite-$ZrO_2$ ceramic with illite clays as sintering aid and strength improver; (e) Alkaline ($Na^+$ or $K^+$) solution activated clays (from Kallukalns and Livani deposits) in compositions with fine fraction of Jekabpils waste dolomite. Material development intended as a new porous ceramics for building material applications.<br>Most of results have been summarised in papers and presented at scientific conferences. |
| 4. The project goal was obtaining of highly porous clay and oxide ceramics, determination of sorption properties and possible practical use of these ceramics.<br>Project objectives (1) Investigation of thermal, physical and chemical processes during firing of various clays and oxides; (2) Determination of pores structure of obtained materials by mercury porosimetry and nitrogen absorption (BET); (3)The possible use of some organic by-products for the increasing of porosity of ceramic materials; (4) Determination of sorption ability of such materials concerning to some organic pollutants in the water; (5) Investigation of various surface activation with task to increase a sorption ability; (6) Determination | Described in details project tasks was implemented and results gained in all components and major results are published and reported in the scientific conferences (in details see p. 2.3.). This leads to clear working program for future research activities. |

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| of filtering and sorption ability of highly porous ceramics | |
| 5. The aim of the sub-project is to study peat and sapropel (organogenic deposits) properties and their application potential. The work tasks of the 1.st year of the project includes sampling of peat and sapropel samples, characterisation of their properties by means of different methods and relations to application options.. | During the 1. year of study major attention was addressed to study in details peat and sapropel (organogenic deposits) properties, their relations to diagenetic transformation processes of natural organic matter as well as to study their application potential. This includes sampling of peat and sapropel samples, characterisation of their properties by means of different methods and relations to application options. Supplementary studies were related to environmental remediation possibilities, both in respect to dredging of eutrophic lakes and complex use of peat and sapropel to develop added value products. Major research results were published and study reaches one National patent. |
| 6. To develop an improved biopreparation with *Rhizobium leguminosarum* estimating microbial viability in suspension and on different carriers and to estimate an effect of the ceramic beads after their use in wastewater treatment as an alternative fertilizer | Gained results are published and it can be concluded that the model system constructed in this study has a potential for further development of the wastewater treatment process in the columns cascade. The porous ceramic beads were shown to be a stable supporting material for microbial immobilization. |

**2.3. Description of gained scientific results**

*(Describe scientific results achieved during reporting period, give their scientific importance)*

The project was organised as integrated study between 6 research groups from several institutions (mainly University of Latvia and Riga Technical University) coordinated in manner from bottom to up-- in particular conditions-- from geological basic studies to intense microbiological studies. The following will shortly describes major results of particular subprojects.

1. **Mineral resources studies**. Besides traditional high quality Latvia mineral resources (e.g. dolostone, clay, sand and gravel, and peat) during the first year substantial attention was addressed to evaluation of untraditional for Latvia mineral resources like flint, ochre, salt, coloured stone, amber) finalised by several published original per reviewed monographs and therefore this area for future studies is finalised for years. Palaeogeographical studies for prognosis of sand and gravel deposits are finalised in doctoral thesis of M. Krievans.

At this phase of the project evaluated clay deposits and selected several most suitable (Kuprava, Nīcgale un Tūja) for studies in details during the second phase, where the most attention will be forwarded to development of new technologies and potential market high value added products.

Evaluated indirect geological research methods (geophysical studies) in particular for applications to peat studies to reach instrumental qualities of data and there is possibility to develop the method during the second phase of the project to finalise with methodology of

this method for applied geological field studies, mostly for road constructions and quality control.

**2. Studies in details clays regarding applications for cosmetics demonstrate** that illite clays from Latvia with fraction under 2 μm mixed with 50% (mass/mass) glycerol/water solution showed the ability to partially absorb UV radiation. The absorption ability was influenced by the mineralogical and chemical composition and the amount of clay fraction added. The highest UV absorption ability showed samples with the highest content of iron oxide in the chemical composition and with the highest concentration (30 mass%) of clay fraction. From the obtained data sun protection factor (SPF) was calculated, giving the highest SPF 2,8. The addition of clay fraction also improved the stability of oil-in-water emulsions. The stability was influenced by the mineralogical composition, chemical treatment of clay samples and added concentration. The most stabile emulsions were obtained by the addition of 10 mass% untreated clay fraction with the highest content of clay minerals. The obtained results show that illite clays from Latvia with fraction under 2 μm can be used in cosmetic product like sunscreen as natural UV filter and possibly emulsifier. Scientific importance of the current work is confirmed with PhD thesis of I.Dušenkova.

Scientific research about application of biodegradable composite materials as alternative daily cover materials in waste landfills and investigation and criteria of clay properties for application in development of biodegradable composite materials was gathered and investigated. Based on the literature data, a sprayable cover material is the most convenient for daily use. The main components used to develop biodegradable composite materials are clay (10% - 90%), fiber (20% - 60%) and a polymer (0,5% - 15%). The particle size of clay material should be within the range of 0,001 – 0,1 mm. Despite the fact that montmorillonite containing clays are mostly used because of their rheological properties (plasticity and viscosity), rheological properties of illite containing clays also can be used in development of biodegradable composite materials for application as waste landfill covers. It is possible to develop a sprayable alternative daily cover material by using polymer materials and fibres and locally available clays, which would allow greater use of the resources available in Latvia. The literature review about criteria of clay properties for application in development of biodegradable composite materials are essential in experimental design and will be used in development of daily cover from Latvian illite clays containing composite materials. Scientific importance of the literature research about application of biodegradable composite materials as alternative daily cover in waste landfills is confirmed with an article. Technological method for obtaining granular sorbents (hollow spheres) from polystyrene pellets, binder and clays from Liepa deposit with laboratory scale homemade rotary granulator was developed. Mechanical properties, structure and surface morphology of the obtained hollow spheres were investigated. The process includes these steps in this direct order – inserting polystyrene pellets in the granulator cylinder, addition of clay powder, setting the mixing speed and turning on the motor, praying the binder solution, spraying the clay powder on the wet hollow spheres until they become lighter in colour and the clay coverage on the spheres is 0,5-1,5 mm. Then the spheres are calcined in 5 different temperatures - 950, 1000, 1050, 1100 and 1150$^{o}$C. The results showed that the calcination temperature affect the mechanical strength of the obtained material - mechanical strength increases by increasing the calcination temperature. The surface morphology is not influenced by the calcination temperature – all sample particles have spherical shape with a number of different sized bumps on the surface obtained from uneven deposition of clay particles on the hollow sphere surface. Diameter of these bumps is 20–27% from the sphere diameter. The outcome of the method is ~ 57%, which could be increased by recycling the clays from the granulator cylinder walls. This method provides homogeneity of the obtained hollow sphere

properties which is essential in further research about the application possibilities of this material.

4.3. **Ceramics studies demonstrate** the objectives of the 1st period have been reached. In the light of research that has been dedicated to the development of energy saving ceramic materials, the main scientific and practical conclusions are as follows:

- It is possible to "deform" the initial structure of clay mineral illite (it is the main component of local clays), which is a prerequisite for development of ceramic material at lower (in comparison to traditional) firing temperatures. It is also possible to obtain new phases (for example, hydrated sodium alumosilicate) this way, which have a potential use for creation of new binders. The most important changes with illite happen by chemical activating using 4-6 M alkaline solutions and, especially, by dehydration in process of thermal treatment at about 600 °C.

  The influence of KOH on the destruction of illite structure is of greater extent if compared with same concentration NaOH solution. From the practical point of view the temperature of firing of corresponding material has been decreased by about 150 – 200 °C. The resulting materials are intended for the main application in construction industry. The compressive strength of these materials is in the range of 10 – 18 MPa depending on the used clay. The formation of sodium alumohydrosilicate ($Na(AlSiO_4)_6 \cdot H_2O$) is characteristic for clays with high carbonate content (CaO+MgO content of about 9-12 %, loss of ignition 14-15 %) after treatment with NaOH. These materials harden at 100 °C, reaching high enough strength (over 15 MPa).
- Porous cordierite-containing material has been developed using local clays and sand as well as synthetic additives in order to ensure proper stoichiometry. This cordierite ceramic material forms at already 1200 °C (in comparison with traditional 1400 °C) in the presence of liquid phase. Materials with low density (near 1 g/cm$^3$), high porosity (over 50 %) and compressive strength of about 5 MPa can be obtained. The material is suitable for the use in ceramic filtering systems, for example – hot exhaust gas purification systems.
- It is shown that illite mineral fraction has high stability against 1-6 M alkali solutions – its 2:1 structure only weakens, but does not fall apart. On the other hand, thermal treatment at 600 °C has a higher influence. Therefore thermally treated illite mineral is an active sintering aid and a promising candidate in compositions with synthetic components for obtaining of new high-temperature crystalline phase-containing refractory products.
- Thermally treated illite mineral fraction combined with 20-50 % $Al(OH)_3$ forms new, dense ceramic materials with varying colour palette. Sintered samples can be characterized with density of 2.2 – 2.5 g/cm$^3$ and high compressive strength (about 170 MPa). Such ceramic products can be used either as high durability floor tiles or as a various construction elements in general, including load-bearing parts. The use of this material as a colouring high-temperature pigment (in form of a powder with particle size in large nanometer scale) should also be considered.

The recycling of Jekabpils waste dolomite fine fraction into new materials is problematic since the procedure temperature should be low. However it is possible to obtain synthetic gypsum ($CaSO_4 \cdot 2H_2O$) by using chemical treatment with concentrated sulphuric acid.

**4. Highly porous ceramics with activated surface.** The major results can be summarised as: (1) There were determined diverse processes in Devonian and Quaternary clays by obtaining ceramic pellets during sintering at various temperatures; (2) It was determined a dependence of pore size, pore volume, and specific surface area on the initial composition, grain size distribution in the investigated clays and sintering temperature; (3) An addition of glycerine (by-product by refinement of rape oil) improves the pore structure and

sorption ability of ceramic granules; (4) Depending on clay type and sintering conditions pellets can reduce the level of organic pollution; (5) The sorption ability of ceramic pellets slightly increases after irradiation with accelerated electrons; (6) The sorption ability concerning to various pollutants is selective and depends on the type of clays (Devonian or Quaternary clays); (7) Nanodisperse additives improves mechanical properties and changes thermal conductivity of highly porous oxide ceramics.

**5. The peat, gyttja, clay properties and possible modification studies.** Within the first year of the project extensive field sampling of peat and sapropel were done to reflect environmental variability and impacts of differing development conditions on the composition of sedimentary and peat material. For characterisation of full sample profiles besides to their dating, biological composition, pollen analysis, also multiproxy physical and chemical analysis were done including for example elemental analysis (C, H, N, O, S, metal concentration (18 metals), spectroscopic analysis (UV-Vis, FTIR, Fluorescence spectra, fluorescence 3D EEM, $^{13}$ C NMR, $^{1}$H NMR etc). Contribution of environmental impacts of climate change and land use change *versus* human impacts were studied and critical impacts were identified and described. Multiproxy approach on analysis of peat and lake sediments to characterise humification conditions has been applied for first time and obtained results support further studies on application potential of sedimentary material.

**4.6. Microbiological studies.** Nitrogen-fixing bacteria are widely used in agriculture as a biofertilizer to stimulate the plant growth. The aim of these experiments was to develop biopreparations of *Rhizobium leguminosarum* with an enhanced activity/viability by immobilizing bacteria on an appropriate carrier/substrate. Five sterile materials were compared for immobilizing, i.e., peat, clay powder, two types of oval ceramic aggregates and cylindrical ceramic beads fabricated by different technologies. Viability of *R. leguminosarum* during storage was influenced by both, type of carrier and temperature. The best results were obtained for biopreparation of *R. leguminosarum* immobilized on peat and stored either at -18°C or +4°C. These samples contained at least $10^7$ CFU/g substrate, and therefore could be considered as an appropriate biofertilizer. During the pot experiment, formation of root nodules on the roots of beans and faba beans in the presence of two strains of *R. leguminosarum* was shown to be plant species-specific. Further study is necessary to test the developed biopreparations under field conditions.

The suitability of ceramic beads for immobilization of N- and P-utilizing microorganisms in the wastewater treatment process, as well as the further use of ceramic beads as alternative fertilizer was tested in the experiments with synthetic wastewaters. After 42 days experiment in the columns cascade, formation of crystals on the beads surface was detected. Concentration of N/P/K achieved up to 1.4/0.6/0.5 g/kg beads, respectively. Comparison of rye and cress response to the presence of the used ceramic beads in loamy sand soil showed the plant species specific effect after a 21-day vegetation experiment. An increase of dry mass of aboveground biomass for rye and cress was 11.2% and 20.0%, respectively, as compared to control without beads. It can be concluded that the model system constructed in this study has a potential for further development of the wastewater treatment process in the columns cascade. The porous ceramic beads were shown to be a stable supporting material for microbial immobilization. The scheme of further experiments can be modified by shortening the retention time of wastewater in the columns as well as optimizing the "beads : liquid phase" ratio.

## 2.4. Further research and practical exploitation of the results

*(Describe further research activities that are planned, describe possibilities to practically exploit results)*

Future research activities are described in work program is underway and as scientific report of the 2nd phase will be presented by March 2016. This will finalize initiated experimental studies in specific regarding clay and peat modifications.
In respect to geological studies major attention will be concentrated on Quaternary geological deposits forming regularities (deglaciation models developed) to reach suitable clay and sand deposits as raw material for new technologies and products. Therefore corresponding field and sampling activities for test material collection will be performed for studies in the 3 other research groups of this project. As important task is to develop geophysical methods (georadar) suitable for instrumental accuracy regarding depth of peat deposits and applications to road construction geotechnical studies in details.
In respect to clay studies in details further research will be aimed to obtain clay fraction under 2 μm using spray drying and more detailed research about the influence of illite clay addition and various parameters on the stability of oil-in-water emulsions. The achieved results will be used to develop ecological cosmetics containing illite clays. To evaluate the application possibility of Latvian illite clays in development of biodegradable cover materials, influence of different clays and their concentration on the formation properties of the cover material layer will be investigated. Further research about the granular sorbents (hollow spheres) will include investigation of porosity and sorption properties of the material, obtained with different parameters, in order to develop products for application in agronomy and ecology.
Regarding development of ceramics studies is concluded, that future development of the study will concentrate on (a) enlargement of the basis of illite clays suitable for 'geopolymer' synthesis to obtain materials with relative low temperatures and higher possible compressive strength; (b) using of mixes from different clays and fly ashes to reduce the global warming potential and impact of by-products (fly ashes) on environment; (c) functionalizing of different substrates (e.g., cellulose fibers) by clay or clay mineral – illite nanoparticle deposition to improve, e.g., its resistance to temperature; (d) use of organic templates (e.g. wood) to reproduce its unique morphology to obtain new ceramic materials, for example, for medicine.
Several particular studies are underway regarding investigation of clay high porous ceramics technology development and target oriented properties of product development.
The study continuation will include modification options, studies of humic substances isolated from peat and sapropel, their structure, as well as their application possibilities.
Regarding development of microbiological studies the scheme of further experiments can be modified by shortening the retention time of wastewater in the columns as well as optimizing the "beads : liquid phase" ratio. In respect to f nitrogen-fixing bacteria used in agriculture as a biofertilizer to stimulate the plant growth urther study is necessary to test the developed biopreparations under field conditions.

**2.5. Dissemination and outreach activities**
*(Describe activities that were performed during reporting period to disseminate project results)*

Project development and particular activities and recent results are reflected in the project homepage (in Latvian) - see www/lu.lv/vpp/. There are number activities performed including presentations at National Radio, participation in science popularisation events Scientists Night ("Zinātnieku nakts"). To wide range of users are addressed most of scientific monographs, but still by content are in a range of scientific books. Research within the project about the application of Latvian clays in cosmetics was disseminated to the public with a popular-science publication "RTU researcher Inga Dušenkova is looking for wider application of

Latvian clays" in newspaper Latvijas Avīze on the 1st April 2015 and with an interview "Application of Latvian clays in cosmetics" in Latvian Radio 1 on the 23rd April 2015. Most of outreach activities are coming out from peat, gyttja and microbiological studies and are well known by publications in National newspapers and popular scientific magazine "Ilustrēta Zinātne".
Specifically should be mentioned traditional dr. R. Svinka cooperation and scientific expertise in development and evaluation of pupils (Secondary School grade) scientific works usually related with mineral resources, chemical and technological processes.

Most of scientific results are published, including 4 articles (*SCOPUS*, SNIP > 1) and 3 articles included in *SCOPUS* (SNIP<1), EBSCO, VINITI, Chemical Abstracts databases. Results are presented in 5 original scientific monographs, and most of the program 1st stage research results are concentrated in 3 protected doctoral thesis.
As particular high rate should be recognised in respect to participation in International scientific conferences (5 conferences and abstracts are published), and there are number of participations National scale Scientific conferences (11 presentations performed with published abstracts) with participation of project social partners from industry. For this cooperation during the University of Latvia Annual Scientific Conference particular section with number of presentation was organised to spread out project scientific results (in details see- http://www.geo.lu.lv/petnieciba/lukonferences/petniecibalukonferences/lietiska/ ).

Besides developed new research methods and methodology and one National patent is registered.

**Publications**

***Original scientific article (SCOPUS)(SNIP>1)***

*1.* Berzins A., Petrina Z., Nikolajeva V., Svinka R., Svinka V., Strikauska S., Muter O. 2015. Characteristics of a Ceramic Carrier after Wastewater Treatment Process in the Model Column Cascade with Ethanol Addition. The Open Biotechnology Journal 9, 76-84.
*http://benthamopen.com/contents/pdf/TOBIOTJ/TOBIOTJ-9-76.pdf*

2.Dabare, L., R.Svinka. Characterization of porous ceramic pellets from Latvian Clays. Chemija. 2014. vol. 25. No. 2. p. 82–88. ISSN:0235-7216
*http://www.scijournal.org/impact-factor-of-CHEMIJA.shtml (SCOPUS)*

3.Stankevica, K., L.Kalnina, M.Klavins, A.Cerina, E.Kaup (2015) Reconstruction of the Holocene palaeoenvironmental conditions accordingly to the multiproxy sedimentary records from Lake Pilvelis, Latvia, *Quaternary International*, 72, 1-14.
*http://www.sciencedirect.com/science/article/pii/S1040618215001226*

4.Zake-Tiluga, I., R.Svinka, V.Svinka. Highly Porous Corundum – Mullite Ceramics – Structure and Properties. *Ceramics International*, 2014, vol. 40, iss. 2, pp. 3071.-3077. ISSN 0272-8842.
*http://www.sciencedirect.com/science/article/pii/S0272884213012443*

***Original scientific article (SCOPUS)(SNIP>1) (EBSCO, VINITI, Chemical Abstracts)***

1. Rundans,M., G.Sedmale, I.Sperberga, I.Pundiene. Development of cordierite ceramics from natural raw materials. Advances in Science and Technology, Vol. 89, 2014, pp. 94-99.
*http://dx.doi:10.4028/www.scientific.net/AST.89.94*

2. Sedmale, G., I.Sperberga, M.Rundans, L.Grase. Different treatment application of illite clay for low temperature ceramics. Advances in Science and Tehnology, Vol.92, 2014, pp. 62-67.

http://dx.doi:10.4028/www.scientific.net/AST.92.62

3. Medne, O., R. Serzane, L. Berzina-Cimdina. Composition for alternative daily cover materials with a perspective of usage of Latvian local resources. *Material Science and Applied Chemistry*, 2015, No. 32, 45-48.
https://ortus.rtu.lv/science/lv/publications/20943

***Reviewed scientific monographs***

1. Segliņš, V. 2015 Aiz dzintara spīduma. Daugavpils Universitāte, akadēmiskais apgāds "Saule", 170 pp.
2. Segliņš, V. 2015. Sāls druska. Daugavpils Universitāte, akadēmiskais apgāds "Saule", 150 pp.
*Iesniegts IZM grāmatas formātā.*

3. Segliņš, V. 2015 Dārgakmeņi un rotakmeņi. Daugavpils Universitāte, akadēmiskais apgāds "Saule", 144 pp.
*Iesniegts IZM grāmatas formātā.*

4. Segliņš, V. 2015 Raibas pēdas akmenī un mums visapkārt. Daugavpils Universitāte, akadēmiskais apgāds "Saule", 88 pp.
*Iesniegts IZM grāmatas formātā.*

5. Krievāns, M. 2015. Hidrogrāfiskā tīkla veidošanās Lejas Gaujas senielejā pēdējā apledojuma beigu posmā. Rīga, Latvijas Universitātes akadēmiskais apgāds, 132 pp.
*Iesniegts IZM grāmatas formātā.*

***New methods***

1. Šiškins, A. "Granulveida sorbenta (dobas sfēras) iegūšanas tehnoloģija, izmantojot Latvijas mālus", 2015.

***Defended doctoral thesis***

1. Dušenkova, I. "Latvijas mālu sagatavošanas tehnoloģijas izstrāde un īpašību pētījumi izmantošanai kosmētiskajos produktos", aizstāvēts 2015. gadā.
Pieejams internetā: https://ortus.rtu.lv/science/lv/publications/19817-Development+of+preparation+technology+and+investigation+of+properties+of+Latvian+clays+for+application+in+cosmetic...

2. Krievāns, M. 2015 „Hidrogrāfiskā tīkla veidošanās Lejas Gaujas senielejai pieguļošajā teritorijā Vēlā Vislas apledojuma deglaciācijas laikā"
Disertācijas teksts pieejams https://dspace.lu.lv/dspace/bitstream/handle/7/28297/298-46546-Maris_Krievans_2015.pdf?sequence=1&isAllowed=y

3. Mahņicka-Goremikina, L.. Sintēzes apstākļu un leģējošo piedevu ietekme uz porainas augsttemperatūras keramikas īpašībām un struktūru. Rīga, 2015, 136 lpp.
Pieejams elektroniski- https://ortus.rtu.lv/science/lv/publications/20334

***Interactive events to promote the process and results of the programme.***

***Conferences***

LU 73. konferences Lietišķās ģeoloģijas sekcija- organizēta tieši VPP rezultātu apspriešanai. Ziņojumi un prezentācijas (18 ziņojumi un 6 stenda ziņojumi) pieejami elektroniski: http://www.geo.lu.lv/petnieciba/lukonferences/petniecibalukonferences/lietiska/

Konferences tēzes pieejamas elektroniski: http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf

***Presentations in International conferences***

1. Dudare, D., M.Klavins (2014) The interaction between humic substances and metals, depending on structure and properties of humic substances. In: Book of Abstracts of the 17th Meeting of IHSSIonannina, Greece, 2014, 11-12.

2. Klavins, M., O.Purmalis (2014) Diagenesis of structure and properties of humic substances. In: Book of Abstracts of the 17th Meeting of IHSSIonannina, Greece2014,1-2.

3. Klavins, M., O.Purmalis (2014) Variability of humic acid properties depending on their precursor material: a study of peat profiles Geophysical Research, 2015, Abstracts, 17, EGU2015-8994.

4. Sperberga, I., M.Rundans, A.Cimmers,L.Krage, I.Sidraba. (2015). Mechanical properties of materials obtained via alkaline activation of illite-based clays of Latvia. 1st International Conference on Rheology and Modeling of Materials", publicēts Journal of Physics : Conference Series vol. 602 (2015; doi: 10.1088/1742-6596/6021/012007.

5. Sperberga, I., G.Sedmale, M.Rundans, A.Cimmers, V.Seglins.(2014). Quaternary clays of Latvia for chemical and thermal activation. In: Scientific Research Abstracts of Internat. Conf. on Applied Mineralogy & Advanced Materials, June 7-12, 2015, Castellaneta Marina, Italy, Vol. 4, 2015, 20-21.

***Presentations in Latvian conferences***

1. Dabare, L., R.Svinka, V.Svinka. Ammonia removal from water solution by adsorption on porous caly ceramic pellets, 55th International Scientific Conference of the Riga Technical University, Riga, 14-17 October 2014. 45.
2. Damberga, M., I.Pudže, L.Dabare,R.Švinka. Atšķirīgu kvartāra mālu keramikas sorbcijas īpašības. Ģeogrāfija, Ģeoloģija. Vides zinātne. LU 73. Zinātniskā konferences referātu tēzes, Latvijas Universitāte, 2015,267-269. (ISBN 978-9984-45-958-5); http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf;
3. Krūmiņš,J., M.Kļaviņš, V.Segliņš (2015) Zemā tipa kūdras sadalīšanās procesu raksturošana izmantojot 3D fluorescences metodi. LU 73 zinātniskā konference, lpp. 355 – 356. Pieejams internetā: http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf
4. Leščinskis, O., R.Švinka, V.Švinka. Keramikas granulu absorbcijas spējas izmaiņa. Ģeogrāfija, Ģeoloģija. Vides zinātne. LU 73. Zinātniskā konferences referātu tēzes, Latvijas Universitāte, 2015,297-299. (ISBN 978-9984-45-958-5); http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf;
5. Randers, M., Sedmale. Diferencēti apstrādātu mālu struktūra un īpašības Ģeogrāfija, Ģeoloģija. Vides zinātne. LU 73. Zinātniskā konferences referātu tēzes, Latvijas Universitāte, 2015, 309-310.lpp. (ISBN 978-9984-45-958-5;). http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf
6. Rundāns, M., Šperberga, G.Sedmale. Poraina kordierīta keramika ar Latvijas kvartāra mālu," Ģeogrāfija, Ģeoloģija. Vides zinātne. LU 73. Zinātniskā konferences referātu tēzes, Latvijas Universitāte, 2015, 310-311.lpp. (ISBN 978-9984-45-958-5).

http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf;

7. Svinka, R., O.Lescinskis, V.Svinka. Activation of ceramic surface with accelerated electrons. 55th International Scientific Conference of the Riga Technical University, Riga, 14-17 October 2014 p.46.
8. Vecstaudža D., Štelmahere S., Strikauska S., Grantiņa-Ieviņa L., Muter O. Dažāda izmēra koksnes bioogles frakciju iuetekme uz mikroorganismu aktivlitāti un *Secale cereale* L. augšanu. LU 73. zinātniskās konferences Lietišķās ģeoloģijas sekcijas sēde, 2015.g.06.februārī. Ģeogrāfija. Ģeoloģija. Vides zinātne. Referātu tēzes. Rīga: Latvijas Universitāte, 2015, lpp. 319-320. *http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf*
9. Zake-Tiluga, I., R.Svinka, V.Svinka, T.Fey Thermal conductivity of porous $Al_2O_3$ – mullite ceramic. 55th International Scientific Conference of the Riga Technical University, Riga, 14-17 October 2014, Abstarcts, p.44.
10. Zembaks, A., V.Švinka, R.Švinka. Augsti poraina Tūjas mālu keramika. Ģeogrāfija, Ģeoloģija. Vides zinātne. LU 73. Zinātniskā konferences referātu tēzes, Latvijas Universitāte, 2015,332-333. (ISBN 978-9984-45-958-5); *http://www.geo.lu.lv/fileadmin/user_upload/lu_portal/projekti/gzzf/Konferences/Tezu_krajumi/A5_kopa_gala_versija_2015.pdf*
11. Žvaginа S., Petriņa Z., Nikolajeva V., Lielpētere A. Immobilization of root nodule bacterium *Rhizobium leguminosarum* biovar *viciae*. Abstract of the 73rd Scientific Conference of the University of Latvia. Environmental and Experimental Biology, 2015, 13, 49.
    http://eeb.lu.lv/EEB/201503/EEB_XII_1_abstracts.pdf

***Popular-science publications***

1. Kuzmina, I. "RTU pētniece Inga Dušenkova meklē plašāku pielietojumu Latvijas mālam". Latvijas Avīze, 2015.gada 1.aprīlī. *http://www.la.lv/ja-strada-zinatne-vari-mainit-pasauli/*
2. „Ilustrētā zinātne" raksts „Notekūdeņi palīdzēs pabarot Kultūraugus", 2014.g.augusts (8/2014)

***Radio broadcasts un interviews***

1. Intervija ar Ingu Dušenkovu "Latvijas mālu izmantošana kosmētika" Latvijas Radio 1 raidījumā "Zināmais nezināmajā", 2015.gada 23.aprīlī. *http://lr1.lsm.lv/lv/raksts/zinamais-nezinamaja/latvijas-malu-pielietojums-kosmetika.a51027/*

2. Raidījums „Zināmais nezināmajā", LR1, red. Olga Rimšāne, 2014.g. 3.novembrī 10.30.-11.00. Piedalījās: A.Bērziņš, V.Nikolajeva, R.Švinka http://lr1.lsm.lv/lv/raksts/zinamais-nezinamaja/par-notekudenju-attiiriishanu-un-parstradi.a44525/

3. Zinātnieku nakts, 2014.g.26.septembrī. "Kristālu veidošanās notekūdeņos", prezentēja A.Bērziņš (pasākuma programma: *http://www.lu.lv/fileadmin/user_upload/lu_portal/zinas/Zinatnieku_nakts_2014.pdf*)

## Economic performance indicators

*Latvian patent*

1. M.Kļaviņš, J.Krūmiņš, S.Bunere (2015) Soil substratum for biological agriculture and method of its obtaining, LV15013 from 05/03/2015

*http://www.lrpv.gov.lv/sites/default/files/20150620.pdf*

Leader of the project 3 _____ Valdis Seglins

## PART 3: INFORMATION ABOUT PROGRAM FINANCE

The short information about the use of program finance

The total available funding for Programme I stage was EUR 425 502. The costs for Programme stage I are divided in percentage as follows: 75% for salaries, 22% for goods, services and materials, and 3% for fixed capital formation.