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OPTIMIZING SUSTAINABLE MATERIAL SELECTION FOR AIR CONDITIONERS IN A SUPPLY CHAIN

OPTIMIZIRANJE IZBIRE TRAJNOSTNIH MATERIALOV ZA KLIMATSKE NAPRAVE V DOBAVNI VERIGI

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In order to cut their carbon footprint and promote environmental sustainability, the majority of businesses have now turned towards sustainable practises in their manufacturing processes and supply networks. The use of sustainable materials has drawn a lot of attention recently as a crucial step in accomplishing these goals. Choosing the material that is most suited for a product can be difficult, despite the fact that there are many sustainable materials available. This study uses machine learning – a random forest algorithm and multi-criteria decision analysis (MCDA) to optimise the use of sustainable materials in supply-chain operations. The study uses machine learning algorithms to analyse data on different sustainable materials, their characteristics and their effects on the environment. The study also investigates how an optimised material selection affects the whole supply chain, including the production, packing and shipping operations. The research offers a complete strategy for reducing the environmental effect of industrial processes by combining approaches from material engineering, supply chain management and machine learning. The novelty of this work resides in its integration of material engineering and machine learning strategies to enhance the supply chain choice of sustainable materials. As a notable example, the study highlights the potential of mycelium as a sustainable material for air conditioner components. Mycelium's unique properties, such as its biodegradability, lightweight nature and adaptability position it as a promising candidate, enhancing the environmental profile of air conditioners. By incorporating mycelium-based components, manufacturers can significantly reduce carbon emissions, resource consumption and waste generation throughout a product's lifecycle. This investigation underscores both the viability of mycelium and the broader significance of innovative material choices in reshaping industries towards a more sustainable future. Through such advances, this research not only contributes to the air conditioning sector but also establishes a paradigm for sustainable material adoption with far-reaching positive implications.

Keywords: random forest algorithm, sustainable materials, multi-criteria decision analysis, supply chain

Zaradi zmanjševanja ogljičnega odtisa in promocije trajnostno vzdržnega okolja se je glavnina podjetij usmerila k trajnostni praksi v svojih proizvodnih procesih in dobavnih verigah. Za dosego tega cilja se kot ključne komponente v uporabi pojavljajo novi trajnostni materiali. Izbira najbolj primernega trajnostnega materiala za določen izdelek je lahko zelo težka, čeprav je na razpolago mnogo le-teh. V pričujoči študiji avtorja opisujeta uporabo strojnega učenja in sicer algoritma naključnega gozda (RFA; angl.: Random Forest Algorithm) in analizo odločitve na osnovi več kriterijev (MCDA; angl.: Multi Criteria Decision Analysis) za optimiziranje uporabe trajnostnih materialov v dobavni verigi. V študiji sta avtorja uporabila algoritme strojnega učenja za analizo podatkov različnih trajnostnih materialov, njihovih lastnosti in njihovega vpliva na okolje. V študiji sta prav tako raziskovala kako izbrani optimizirani material vpliva na celotno dobavno verigo, ki je vključevala proizvodnjo, embaliranje, pakiranje in vrste transporta. Izdelana študija ponuja celovito strategijo zmanjševanja vpliva industrijskih procesov na okolje s kombiniranjem pristopov materialnega inženiringa, menedžmenta (upravljanja) dobavne verige in strojnega učenja. Ta raziskava je primer uporabe novega pristopa pri združevanju strategij materialnega inženiringa in strojnega učenja za povečanje uporabe trajnostnih materialov v dobavnih verigah. Kot tipičen primer sta avtorja v študiji osvetlila potencial uporabe micelija kot trajnostnega materiala za komponente klimatskih naprav. Micelij (podgobje ali mrežasto razrasle nitke) ima enkratne lastnosti; kot so njegova biološka samo-razgradnja, majhna gostota in prilagodljivost. Zato se ta naravni material uvršča med obetavne kandidate za uporabo kot okolju prijazen material v klimatskih napravah. Z vključitvijo komponent na osnovi micelija bi lahko proizvajalci občutno zmanjšali ogljični odtis (emisije ogljikovega dioksida), porabo surovin in nastajanja odpadkov v času njihove uporabe oziroma dobe trajanja. V tej raziskavi avtorja ne opozarjata samo na možnosti uporabe micelija temveč tudi na širši pomen izbire inovativnih materialov pri preoblikovanju in usmerjanju industrije k bolj trajnosno usmerjeni prihodnosti. S takšno usmeritvijo izvedena raziskava ne prispeva samo k razvoju novih klimatskih naprav, temveč je tudi zgled za večjo uporabo drugih trajnostnih materialov z daljnosežnimi pozitivnimi učinki.

Ključne besede: algoritm naključnega gozda, trajnostni materiali, analiza odločitve na osnovi več kriterijev, nabavna veriga

1 INTRODUCTION

Companies all over the world are increasingly focused on sustainable development to lessen their environmental impact, enhance their environmental performance and encourage a wise use of natural resources. The selection of sustainable materials, which have little environmental effect throughout their life cycles, is a key component of sustainable development. Choosing the right material for a product may be difficult, especially when other issues are taken into account, such as price, availability, quality, supply chain and environmental effect.

This project uses environmental impact reduction and machine learning to optimise the use of sustainable materials throughout a supply chain. In order to choose the

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most ecologically friendly materials, the study explores machine learning approaches that can analyse historical data of different materials, including their qualities and environmental effect. This study uses advanced optimisation techniques like random forest algorithm and MCDA to find sustainable materials with low carbon, energy footprint, toxicity and water usage, as well as materials that are recyclable.

This research looked at sustainable materials in a variety of scenarios. However, it was primarily concerned with environmental evaluations and did not provide systematic insights into optimisation approaches for sustainable material selection. The innovative aspect of this work is the integration of machine learning techniques with materials engineering, which allows the optimisation of material sustainability in supply chains.

A machine-learning random forest algorithm is used in this study because of its capacity to handle large volumes of data and deliver insights into complicated challenges. The algorithm can detect trends in past data by analysing it. It can find patterns in the selection of sustainable materials, identify the best suited resources for a specific product, and optimise the material selection across the whole supply chain by analysing historical data.

This study incorporates sustainability by incorporating sustainable development principles into machine learning and optimisation methodologies. It does not only encourage sustainable growth, but also provides a cost-effective strategy for material selection by minimising the environmental impact while preserving the product quality and supply-chain efficiency.

The study applies the multi-criteria decision analysis (MCDA) optimisation approach, assessing potential sustainable material solutions based on numerous factors. The MCDA model allows for the selection of sustainable materials based on a mix of environmental, social and economic criteria across several industries.

The question arises why we chose air conditioners. The reason behind the selection of air conditioners as the focal application for this research stems from their substantial energy consumption and environmental impact. Air conditioners are widely used across the globe, particularly in regions with hot climates, contributing significantly to electricity consumption and consequently greenhouse gas emissions. They are therefore a suitable target for sustainability advancements. Several factors make air conditioners a suitable choice for this study:

Energy Consumption: Air conditioners are known for their energy-intensive operation, which often relies on fossil fuels for electricity generation. Optimizing the materials used for air conditioner components can lead to a reduced energy consumption and lower carbon emissions.

Environmental Impact: Air conditioners, due to their energy consumption and refrigerants used, contribute to the emission of greenhouse gases and other pollutants. By selecting sustainable materials and optimizing their usage, the overall environmental impact of these devices can be significantly diminished.

Lifecycle Considerations: The lifecycle of air conditioners involves stages like manufacturing, usage and disposal. A sustainable material selection can influence each of these stages, from reducing the raw material extraction and waste generation to improving the energy efficiency during operation.

Global Relevance: Air conditioning is essential in various sectors, including residential, commercial and industrial ones. As a result, improvements in their sustainability can have a broad-reaching impact across diverse industries.

Technological Innovation: The integration of machine learning and optimization techniques for the selection of sustainable materials in air conditioner manufacturing presents an innovative approach to addressing environmental concerns in a practical and impactful manner.

In summary, the goal of this research is to optimise the sustainable material selection in supply chain operations through the use of machine learning techniques, environmental effect reduction, and optimisation approaches such as MCDA. Companies may use the findings of this study to take a more responsible and sustainable approach to material selection while preserving the supply chain efficiency and product quality. This research attempts to decrease the environmental effect by optimising the use of sustainable materials in air conditioner manufacturing processes, using machine learning techniques. The study takes a comprehensive approach, analysing the data on various sustainable materials, their properties and environmental impacts, as well as training machine learning algorithms to select the optimal material based on the criteria like carbon and energy footprint, toxicity, water usage and recyclability. This research integrates material engineering, supply chain management and machine learning approaches to create a comprehensive solution for an environmental impact reduction. The findings of this study have the potential to significantly improve sustainability practises, reduce carbon footprints and provide a more responsible approach to the material selection for the air conditioner manufacture. Finally, this research helps to promote sustainable development practises in the global air conditioning industry.

2 LITERATURE REVIEW

Material selection is a critical aspect of the sustainable supply chain management, and several studies were conducted in this area. A review of the literature conducted for this study identified several works that examined the sustainable material selection in supply chains. However, there is limited research available on the integration of machine learning techniques with materials engineering and optimization approaches.

There is a study on the sustainable material selection in a manufacturing company using MCDA. The authors determined that the environmental impact was the most important criterion for material selection, followed by manufacturing cost and social responsibility. Their study recommended the use of MCDA in the material selection process as it considers multiple criteria in decision-making.[1–3]

A research evaluated the sustainable material selection process in a furniture supply chain and proposed a decision-making model based on the analytic hierarchy process (AHP). Their study revealed that sustainability, cost and supply chain efficiency were the most critical factors, influencing the material selection.[4–8]

A few other articles explored the use of big data analytics and machine learning techniques in the closed-loop supply chain management. They suggested that these techniques can be utilized for predicting demand, optimizing inventory and supply chain network design. They highlighted the importance of collecting large amounts of data related to materials, suppliers and other relevant factors for an effective material selection.[9–13]

A few articles discuss supply chain performances, highlighting the importance of considering environmental, social and economic criteria when selecting sustainable materials. They recommended the use of tools such as life cycle assessment, risk assessment and supplier performance assessment in a material selection process.[14–16]

Lastly, a few researchers explored the use of the multi-criteria decision analysis (MCDA) for the sustainable material selection in various industries. They determined that clustering algorithms, classification algorithms and optimization algorithms are the most appropriate machine learning techniques for a sustainable material selection. They recommended that a material selection process should incorporate factors such as energy consumption, carbon footprint and recyclability to minimize the environmental impact.[17–19]

This review highlights the importance of sustainable material selection in supply chains, incorporating environmental, social and economic criteria. The study aims to integrate machine learning and optimization techniques in a sustainable material selection process and expands the existing research in this area. The study aims to make a significant contribution to the field of sustainable supply chain management by developing a model for a sustainable material selection using machine learning and optimization techniques. The literature review also indicates the gaps that need to be addressed.

Limited Optimization Approaches: The existing research on sustainable material selection often lacks an in-depth exploration of optimization techniques. By incorporating machine learning and MCDA into the process, this study bridges the gap between sustainable material attributes and their optimal application within supply chains.

Insufficient Integration: The integration of machine learning and materials engineering is an underexplored avenue. This research seeks to fill in this gap by creating a holistic framework that seamlessly incorporates materials science and data-driven decision-making.

Real-World Application: While many studies emphasize theoretical aspects, this research strives to provide practical implementation strategies. By focusing on air conditioners as a specific application, the study aims to transform theoretical findings into tangible sustainability improvements in a prominent industry.

Lack of Comprehensive Criteria: Previous works often considered singular criteria for a material selection, neglecting the multifaceted nature of sustainability. By incorporating diverse factors like environmental, social and economic aspects, this study introduces a more comprehensive evaluation model.

Industry-Specific Exploration: The existing literature may lack focus on specific industries, potentially limiting the practical impact of findings. This research addresses this limitation by concentrating on the air conditioning sector, offering tailored insights for a critical field.

In summary, this research seeks to bridge the identified gaps in the existing literature by introducing a comprehensive approach that integrates machine learning techniques and sustainability principles for a material selection. By addressing these limitations, the study not only contributes to academic discourse but also provides actionable insights for the industries striving to make informed, responsible and sustainable material choices.

3 EXPERIMENTAL PART

In recent years, there has been a substantial increase in the use of machine learning (ML) in supply chain activities. Machine learning algorithms can analyse massive volumes of data, detect trends and provide insights into difficult situations, assisting supply chain decision-makers. Machine learning approaches can analyse historical data linked to the qualities and environmental effect of materials, recommend the most suitable alternatives, and optimise material selection decisions in the context of sustainable material selection.

The random forest method is a supervised learning approach used in machine learning for both classification and regression issues. It is based on ensemble learning, which mixes several classifiers to tackle complicated problems and increase model performance. The approach employs numerous decision trees on the subsets of a dataset and takes the average to increase the dataset's predicting accuracy. The ultimate outcome is predicted based on the majority vote of projections from each decision tree. By employing a larger number of trees in the forest, random forest helps to avoid the problem of overfitting. The approach assumes real values for the feature variable and low correlations between the predictions from different trees. The random forest method is preferred because it requires less training time, predicts the output with high accuracy, and retains accuracy even when substantial amounts of data are absent. The technique works by mixing N decision trees to form a random forest and generating predictions for each tree formed in the first step. It entails randomly picking K data points from the training set, creating decision trees associated with the selected data points, and repeating the procedure to determine the number of decision trees to be created.

The programme predicts a new dataset by locating the predictions of all decision trees, and then allocates the new data points to the category that receives the most votes. Overall, the random forest method is a powerful tool for optimising the performance of machine learning models. The random forest machine learning method may be used to optimise a sustainable material selection for air conditioners in a supply chain, decreasing their environmental effect in the long run. The programme can analyse a dataset of various materials used in the manufacture of air conditioners and categorise them based on their sustainability and environmental effect. The algorithm can properly forecast which materials are the most sustainable and have the least environmental footprint by integrating various decision trees and taking the majority vote. This can assist us to make educated material selection decisions and lower the total environmental effect of the air conditioning supply chain. Furthermore, the algorithm's capacity to effectively handle big datasets while maintaining accuracy even with missing data makes it a significant tool for optimising sustainable material choices in a variety of sectors.

This study's approach is divided into two stages:

Phase 1: Combination of data gathering and material selection sustainability criteria

Data collection covers material properties, environmental impact, social responsibility and economic factors. Identification of sustainable material alternatives is based on a review of the literature and expert opinions. We use the multi-criteria decision analysis (MCDA), and select the most sustainable material solutions by allocating weights to different criteria.

Phase 2: Machine learning techniques and the multi-criteria decision analysis

A dataset including information on material attributes and their environmental impact is developed based on the material alternatives chosen. Using clustering, classification and optimisation methods, the dataset is cleaned, pre-processed and analysed. Clustering algorithms group materials based on their qualities, whereas classification algorithms categorise materials based on specific criteria.

Finally, optimisation algorithms choose the most ecologically friendly material options. To validate the efficacy of the suggested technique, the results of the machine learning analysis are compared with the traditional method of material selection using MCDA with the random forest algorithm.

The following stages are included in the experimental process of this study:

1. Data Gathering: Data on the characteristics and environmental effects of various sustainable material alternatives are acquired from reliable sources such as scientific publications and patents. The information is gathered for a variety of parameters, such as carbon footprint, energy consumption, toxicity, water usage and recyclability.

2. Sustainability Criteria: Based on the literature study and expert inputs, a set of criteria for the sustainable material selection in supply chains was identified. These criteria include environmental impact, social responsibility and economic factors.

3. Multi-Criteria Decision Analysis (MCDA): To pick sustainable material alternatives, specified criteria are included into the multi-criteria decision analysis model. The MCDA model weights each factor to prioritise the selection of materials with lower environmental, social and economic effects.

4. Machine Learning Analysis: Machine learning techniques such as clustering algorithms, classification algorithms and optimisation algorithms are used to analyse the selected sustainable material alternatives. The study is carried out on a dataset that was constructed using the environmental effect and property data gathered in step 1.

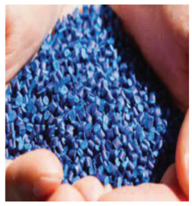
Finally, the proposed methodology and experimental procedure include data collection on material properties and environmental impact, identification of sustainability criteria, selection of sustainable materials using the multi-criteria decision analysis, analysis of selected materials using machine learning techniques, and validation of the effectiveness of the machine learning approach by comparing it with the MCDA model. The study's goal is to help decision-makers choose the most sustainable materials for supply chains.

Material Selection: There are several sustainable materials that could be selected for this study, depending on the specific application and industry. Here are 8 sustainable materials which are considered for this study based on the environmental impact, social responsibility and economic factors as shown in **Table 1**.

Random forest algorithm

As the name suggests, "random forest is a classifier that contains a number of decision trees on various subsets of a given dataset and takes the average to improve the predictive accuracy of that dataset." Instead of relying on one decision tree, random forest takes the prediction from each tree and based on the majority votes of predictions, it predicts the final output. A greater number

Table 1: Material selection

Material	Environmental impact	Social responsibility	Economic factors	Picture
Bamboo	Highly sustainable and renewable	Production can provide income for local communities	Cost-effective and durable for construction and furniture	
Recycled plastics	Reduces waste and pollution	Working conditions of waste collectors and recyclers may be challenging and hazardous	Generally lower cost than virgin plastics	
Hempcrete	Low-carbon and energy efficient	Helps create jobs in sustainable agriculture and manufacturing sectors	More expensive than traditional concrete	
Mycelium	Biodegradable at the end of life cycle, grown using waste materials	Potential to create jobs in sustainable agriculture and manufacturing sectors	More expensive than traditional plastic materials	
Cork	Highly sustainable, harvesting process does not require the tree to be cut down	Helps create jobs in cork production and harvesting	More expensive than traditional wood and other flooring materials	
Recycled steel	Reduces energy consumption and carbon emissions	May provide job opportunities for waste collectors and recycling industries	Can be less expensive than virgin steel due to reduced manufacturing costs	
Straw bales	Highly sustainable and low carbon footprint	May provide new job opportunities for those with less traditional construction experience	Can be cheaper due to a lower cost of raw material	
Natural fibre fabrics	Less impact on the environment, absence of toxic chemicals	Sustainable production may provide job opportunities for farmers and textile workers	More expensive compared to synthetic materials	

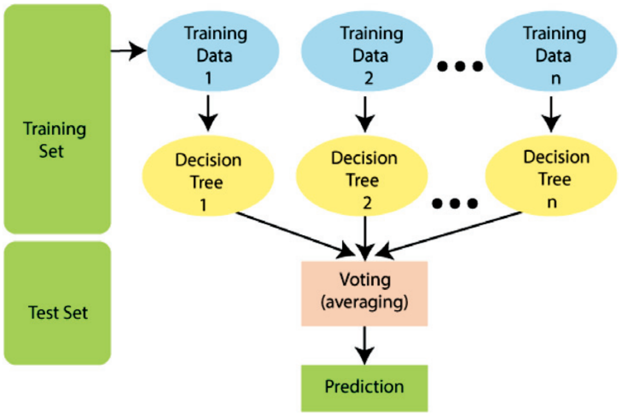


Figure 1: Random forest algorithm sample

of trees in a forest leads to higher accuracy and prevents the problem of overfitting.

The diagram shown in **Figure 1** explains the working of the random forest algorithm.

Random forest is a machine learning algorithm that can be used for classification and regression tasks. The algorithm operates by building a "forest" of decision trees as shown in **Figure 1**, where each decision tree is trained on a random subset of features and data from the training set.

In simple terms, the random forest algorithm creates multiple decision trees and combines their results to make a prediction. It does this by randomly selecting subsets of features and data from the training set to create different decision trees. The algorithm then combines the results of these decision trees to make the final prediction.

Random forest is a popular algorithm because it can handle large datasets with many features and is resistant to overfitting, which is when the algorithm becomes too tuned to the training data and performs poorly on new data.

Based on the results received from the algorithm after providing various data regarding the properties of each material, **Table 2** shows the ranking of the materials with respect to the criteria shown in this table.

Multi-criteria decision analysis

The multi-criteria decision analysis (MCDA) is a method used to evaluate and compare multiple options based on a set of criteria. In this case, the criteria used were environmental impact, social responsibility and economic factors. The weight assigned to each criterion was determined based on the importance placed on each factor by decision-makers, i.e., 40 % for environmental impact, 30 % for social responsibility and 30 % for economic factors.

The weight assigned to each criterion plays a crucial role in the material selection process. For example, if the weight assigned to environmental impact was higher than the weight assigned to economic factors, the material with the lowest environmental impact would be chosen even if it was more expensive. Conversely, if the weight assigned to economic factors was higher, the material with the lowest cost would be chosen regardless of its environmental impact.

Based on the ranks and points assigned in **Table 3**, the MCDA model was used to select the material that best met the criteria set by the decision-makers. The material with the highest score and rank was selected, tak-

Table 2: Ranking of the materials based on the random forest algorithm

Rank	Environmental impact	Social responsibility	Economic factors
1	Mycelium	Bamboo	Recycled steel
2	Hempcrete	Hempcrete	Cork
3	Cork	Cork	Recycled plastics
4	Bamboo	Mycelium	Natural fibre fabrics
5	Straw bales	Natural fibre fabrics	Mycelium
6	Recycled steel	Recycled steel	Bamboo
7	Natural fibre fabrics	Straw bales	Hempcrete
8	Recycled plastics	Recycled plastics	Straw bales

Table 3: Weightage and points table

S. No.	Materials	Environmental impact points (40 %)	Social responsibility points (30 %)	Economic factors points (30 %)	Total points out of 24	Points based on weightage out of 8
1	Mycelium	8	5	4	17	5.9
2	Hempcrete	7	7	2	16	5.5
3	Bamboo	5	8	3	16	5.3
4	Cork	6	6	2	14	4.8
5	Recycled steel	3	3	8	14	4.5
6	Natural fibre fabrics	2	4	5	11	3.5
7	Recycled plastics	1	1	6	8	2.5
8	Straw bales	4	2	1	7	2.5

ing into account the weight assigned to each criterion. Using the MCDA, a comprehensive and objective approach was taken to evaluate and compare different materials.[17–19]

In short, the MCDA model assigned a weight of 40 % to environmental impact, 30 % to social responsibility and 30 % to economic factors. To select the best material based on the above, points were provided based on the materials rank: Rank 1 has 8 points, Rank 2 has 7 points, Rank 8 has 1 point and other details can be seen in **Table 3**.

4 RESULTS

As seen in **Table 3** we found that mycelium is the best alternative component for air conditioners after examining the eight alternative sustainable materials for air conditioners based on environmental impact, social responsibility and economic factors. Regarding its environmental impact, mycelium is a natural, biodegradable and renewable substance; it is a more ecologically friendly alternative than typical insulating materials. Mycelium is produced by fungi from agricultural waste and does not require the use of toxic chemicals. We can lower the carbon footprint of air conditioners by using this material for air conditioning components. Using mycelium encourages social responsibility in a variety of ways. First, it promotes sustainable agriculture practises, green jobs and pollution reduction. Second, the usage of mycelium insulating material can help to develop a market for waste agriculture, thus benefiting local farmers and communities. Regarding economic factors, mycelium insulation manufacture generally operates at low costs, which may greatly cut the air-conditioner production costs. Growing mycelium without the use of artificial fertilisers is both cost-effective and efficient.

Mechanical properties of mycelium

Mycelium as an alternative material in the sustainable material selection for air conditioners using machine learning and aiming at an environmental impact reduction was chosen based on its excellent mechanical properties, sustainability and cost-effectiveness. Machine learning models, specifically the random forest algorithm, were used to optimize the selection of sustainable materials. Mechanical properties of mycelium are shown in **Table 4.**

Table 4: Mechanical properties of mycelium

Material	Density (kg/m^3)	Compressive strength (MPa)	Tensile strength (MPa)	Thermal conductivity (W/mK)
Mycelium	240–420	0.2–1.4	0.2–35	0.032–0.052

5 DISCUSSION

The random forest method is a classification and regression analysis supervised machine learning tool. It is a classification method that models a set of decision trees, each of which divides the data into two classes or conditions at each branch. To achieve high accuracy, the algorithm chooses the most essential attributes for each tree and integrates the results from numerous trees. The random forest algorithm may be used in the context of a sustainable material selection for air conditioners to find the most suitable components based on their environmental effect, social responsibility and economic variables. The model is trained using historical data that relate the material and related metrics for mechanical qualities, environmental effect, social responsibility and economic aspects. In comparison to the other options, the algorithm can optimise the use of mycelium in air conditioner components.

When selecting mycelium as a suitable material for air conditioners, the random forest algorithm examined the mechanical properties of each material and identified mycelium's moderate density, good compressive and tensile strength and low thermal conductivity, recommending it as a suitable material to be used. Furthermore, when compared to other potential materials, the random forest algorithm considered the cost, sustainability and environmental impact to select the most sustainable and cost-effective option.

The application of the random forest algorithm in the context of sustainable material selection for air conditioners yields profound implications, particularly in the identification of mycelium as the top choice. The method considered data and attributes related to mechanical qualities, environmental impact, social responsibility and economic factors, contributing to a comprehensive evaluation of the materials. Let us delve into the implications of mycelium's emergence as the optimal material choice:

Mechanical Properties: The random forest algorithm's consideration of mechanical attributes is crucial. In the case of mycelium, its moderate density, commendable compressive and tensile strength and low thermal conductivity render it a feasible option. This highlights mycelium's potential to fulfil the functional requirements of air conditioner components.

Environmental Impact: The algorithm's capacity to prioritize materials based on their environmental impacts aligns with sustainability objectives. Mycelium's biodegradability and minimal carbon footprint contribute to its prominence. Its natural growth process and low energy requirements further underscore its eco-friendliness, reducing the overall environmental burden associated with the air conditioner production.

Cost-Effectiveness: The integration of economic considerations by the algorithm ensures that material choices are not only sustainable but also financially viable. Mycelium's growth process, which can occur in controlled environments, may lead to cost savings in the long run, as well as potentially reducing waste disposal expenses.

Sustainability Criteria: Mycelium's emergence as the top choice signifies its alignment with a multifaceted set of sustainability criteria. This encompasses not only environmental aspects but also social responsibility and economic viability, demonstrating its ability to contribute to a well-rounded sustainable supply chain.

Innovation and Differentiation: The adoption of mycelium as a material for air conditioner components showcases a commitment to innovation and differentiation. Such a choice sends a strong signal to consumers and stakeholders about the company's dedication to responsible practices and its readiness to embrace novel, environmentally conscious alternatives.

Industry Influence: The choice of mycelium holds the potential to inspire other manufacturers in the air conditioning industry and beyond. As one of the first movers in adopting this innovative material, a company can contribute to shifting industry norms toward greener practices.

While mycelium holds promise as a sustainable material for air conditioner components, there are a few barriers and challenges that need to be addressed before its widespread adoption in actual manufacturing processes. These challenges include the following:

Technical Challenges: Mycelium's growth process can lead to variations in material properties. Ensuring consistent and reliable material characteristics, such as strength and thermal conductivity, across batches is essential for maintaining product quality and performance. Mycelium-based materials might need to undergo rigorous testing to ensure they meet durability and longevity expectations, especially in the demanding operational conditions of air conditioners.

Supply Chain and Logistics: Scaling up the production of mycelium-based materials to meet industry demand may pose challenges in terms of consistent supply and availability. Logistics related to transporting live mycelium cultures or processed materials might need to be addressed, especially for global supply chains.

Waste Management and Disposal: While mycelium is biodegradable, its proper disposal and integration into waste management systems need to be planned to ensure it aligns with the existing disposal infrastructure.

In summary, the implications of mycelium's ranking as the top choice, revealed by the random forest algorithm, extend beyond a mere material selection. They signify a step toward enhanced sustainability, responsible resource utilization and innovation within the air conditioning sector. By showcasing the multifaceted advantages of mycelium, this research not only fosters improved decision-making but also bolsters the overall sustainability landscape.

6 CONCLUSIONS

In conclusion, optimizing sustainable material selection for air conditioners in the supply chain using machine learning for the environmental impact reduction can be an effective approach for reducing the carbon footprint of air conditioning components. Using machine learning algorithms to evaluate the environmental impact of different materials, manufacturers can identify the most sustainable options for their products. The supply chain's selection of environmentally friendly materials for air conditioning components may be improved with the use of machine learning algorithms. Machine learning algorithms such as the random forest algorithm can determine the most environmentally friendly solutions while preserving product quality and cutting costs for the producers by analysing enormous volumes of data on the environmental effects of various materials. According to the study, mycelium is the best product for lessening the environmental effect, increasing social responsibility and economic gains for nearby communities, and supporting sustainable agricultural practises. Overall, the application of machine learning algorithms may help create a more environmentally friendly industry with lower carbon emissions, more social responsibility and financial gains. In essence, the adoption of mycelium in the manufacturing of air conditioners presents both opportunities and challenges. Addressing the barriers through ongoing research, technological advancements and collaboration between material scientists, engineers and regulatory bodies will be crucial to realizing the potential benefits of mycelium while navigating the complexities of real-world manufacturing contexts.

Future scope

Future research on the use of mycelium in air conditioners may concentrate on overcoming its drawbacks and enhancing its mechanical qualities while preserving its benefits for ecological and social sustainability. To change the structure and qualities of mycelium to fulfil the specifications for air conditioner components, new approaches need to be developed. Moreover, additional research is required to look into how mycelium insulation affects the effectiveness and performance of air conditioners. The effects of this material on indoor air quality, noise and energy consumption may be studied and compared to more conventional materials. To ensure the environmental sustainability of mycelium and the sustainability of the mycelium industry, it is also possible to investigate the effects of mycelium production on the ecosystem as a whole. The transition from research to a real-world implementation involves a series of steps, starting with data collection and algorithm training on sustainable material attributes. A validation of the predictions through material testing and collaboration with suppliers helps integrate mycelium-based components seamlessly. Comprehensive lifecycle assessments quantify environmental gains. Manufacturers stand to benefit from enhanced sustainability, product differentiation and long-term cost savings. Supply chain managers gain insights needed for informed decision-making and optimized logistics. Collaboration, pilot projects, continuous improvement and effective market communication are key to transitioning this research into actual sustainable manufacturing practices. However, because mycelium is made of natural fibres, it is sensitive to heat and moisture. Consequently, we can use any of the following techniques: coating mycelium with protective films, thermal treatment, adding chemicals, combining mycelium with other materials, and optimising growing conditions.

7 REFERENCES

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