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EFFICIENCY OF ECO MATERIALS IN CONTEMPORARY INTERIOR DESIGN

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Abstract. This article analyzes the energy and ecological efficiency of natural materials in modern interior design and brings back into discussion the solutions for their implementation in past periods. The research is developed by the method of analysis, information synthesis, deduction and comparison, which creates new premises for the development and evolution of sustainable interior design. The results of the study consist in cataloging data and indices of optimal ecological materials for energy efficiency of spaces and including in the scientific circuit information about the benefits of using clay or clay products for finishing works in contemporary interior design. The results of the study provide an insight into the most effective practices in the use of eco materials for sustainable interior design, with a discrete presentation of concrete historical data on past building experiences. The practical significance of the study is argued by the benefits and advantages offered by local ecological materials in the field of construction and interior design, with the presentation of past experiences and prospects for future implementation as an optimal solution for improving the eco natural system and human living.

Keywords: *sustainability; ecology; clay; decarbonization; tradition.*

Rezumat. Articolul analizează eficiența energetică și ecologică a materialelor naturale în designul interior modern și readuce în discuție soluțiile pentru implementarea acestora în perioadele trecute. Cercetarea este dezvoltată prin metoda analizei, sintezei informației, deducției și comparării, ceea ce creează noi premise pentru dezvoltarea și evoluția designului interior sustenabil. Rezultatele studiului constau în catalogarea datelor și indicilor materialelor ecologice optime pentru eficiența energetică a spațiilor și includerea în circuitul științific a informațiilor despre beneficiile utilizării argilei sau produselor din argilă pentru lucrările de finisare în designul interior contemporan. Rezultatele studiului oferă o perspectivă asupra celor mai eficiente practici în utilizarea materialelor ecologice pentru designul interior sustenabil, cu o prezentare discretă a datelor istorice concrete despre experiențele de construcție din trecut. Semnificația practică a studiului este argumentată de beneficiile și avantajele oferite de materialele ecologice locale în domeniul construcțiilor și designului interior, cu prezentarea experiențelor trecute și a perspectivelor de implementare viitoare ca soluție optimă pentru îmbunătățirea sistemului eco natural și a vieții umane.

Cuvinte cheie: *sustenabilitate; ecologie; argilă; decarbonizare; tradiție.*

1. Introduction

The construction industry plays an important role in stimulating economic progress and improving the quality of life, but at the same time, it also plays a negative role in environmental degradation. Thus, any involvement in researching and identifying ways to protect the environment and promote ecological solutions in the living space is absolutely necessary. In the context of concerns about sustainability and environmental protection, the use of ecological materials has become an increasingly widespread practice. Research on ecological materials in contemporary interior design emphasizes their functional, aesthetic and ecological benefits, their impact on health and the environment, as well as their performance compared to conventional materials. The scientific approach has been concerned with promoting clay-based materials as a local natural material, which has been widely used in the historical past of many peoples. The scientific analysis showed that clay is an economically convenient, practical and applicable resource, but at the same time it is environmentally friendly, energy efficient and renewable, and can contribute substantially to the improvement of the natural ecosystem. The proposed solutions were substantiated by evidence and descriptions of the opportunities and advantages offered by the raw material in the field of construction, with its effect on the climate and the ecological environment of living spaces.

The aim of the material is to analyze the energy and ecological efficiency of the materials used in contemporary interior design and to create new perspectives for the implementation of eco materials used in ancient times to ensure healthy and comfortable ambience in the indoor environment.

The research methods used in this study included analysis, inferences, surveys, case studies and syntheses of practical experiences from the interior design and architecture industry, through which new premises for development and evolution in the field of sustainable interior design are created.

The results of the study provide an insight into the most effective practices in the use of eco materials for sustainable interior design, with a discrete presentation of concrete historical data on past building experiences. The research highlights technical processes and procedures for the implementation of eco materials in the construction sphere from different time periods and regions. The results of the study are notable for the inclusion in the scientific circuit of the multiple benefits of using clay or clay products for finishing works in contemporary interior design. The scientific endeavor is concerned with the promotion of this material as a local natural product, which has been widely used in the historical past of peoples. The scientific analysis shows that clay is a convenient resource in economic, practical and applicable aspects, but at the same time it is also ecological, energetic and renewable, which can substantially contribute to the improvement of the natural eco system. The proposed solutions are substantiated by evidence and descriptions of the opportunities and advantages offered by the raw material in the construction field, with its effect on the climate and ecological environment of living spaces. The contribution of clay used or combined with other natural materials will consist in increasing the quality of human life, purifying the ecological environment, decarbonizing the natural environment and of course reducing the process of global warming, which is such a pressing problem of the contemporary environment. As a result of the research, some recommendations are made regarding the implementation of clay in finishing techniques and solutions in the field

of construction, proposing new research directions, experiments and practices for the sustainable development of the field.

The scientific novelty of the material lies in the identification and determination of energy-efficient and environmentally friendly solutions for interior design and architecture using natural raw materials used in ancient times. It also brings back into the scientific spotlight the advantages offered by local materials, which have multiple environmental and sustainable benefits.

2. Eco Materials and Implementation Methods

Following the analysis of trends in the field of interior design, there is evidence of the development of specific standards applicable to this sector. Often neglected, interior design highlights unique challenges and opportunities related to the human environment, unlike the construction sector, which emphasizes structural and exterior elements. Looking more closely at the issues of ecology and sustainability in interior design, we observe numerous studies and research that have highlighted multiple aspects [1]. One of these aspects refers to the energy and environmental efficiency of the materials used. In this context, the results of calculations regarding the depletion of natural resources, energy consumption, pollutant production and greenhouse gas emissions are important [2]. It is estimated that the architecture industry, including interior design, “consumes 40% of all raw materials and nearly 10% of global energy, thus underscoring the urgent need for sustainable practices” [2]. According to data from a study conducted by the United Nations Environment Programme, the construction industry accounts for approximately 40% of global energy consumption and approximately 24% of global greenhouse gas emissions [3]. The data confirms that the life cycle of interior design projects leaves a significant ecological footprint and that rising energy costs and environmental degradation problems require inevitable sustainable solutions.

There are numerous debates, discussions and publications in the scientific community regarding the functioning of building sustainability assessment systems. All of this highlights the essential role of systems in promoting sustainability objectives in the construction sector. The concept of systems is based on environmental aspects, economic and social factors of sustainability, which tend to provide a nuanced assessment of the sustainable performance of buildings [4]. The premises of sustainable development have been formulated through multiple global events, mentioned in specialized publications [2]. Worldwide, there are approximately 600 sustainability assessment systems developed by government authorities or expert groups [5, 6]. This diversity allows the adaptation of systems to current trends in sustainability for a local, regional or compartment-specific context. In this context, we can mention the role and importance of energy labels recognized by the European Union, offering a set of methods, solutions and investments, applied in the technological process of reducing energy consumption [7].

Particular importance is also given to the methods of assessing the sustainability of buildings, which provide both qualitative and quantitative measures in the assessment process. These systems provide flexibility for buildings to compensate for poorer performance through better categories and, finally, assess the compliance of buildings through certain evaluation criteria or environmental impact credit points [2]. Many researchers talk about an environmental impact assessment based on the life cycle of buildings, and this is a factor of great importance. Often, the Life Cycle Assessment (LCA)

system is combined with the detailed data analysis tool - Building Information Modeling (BIM), for certain regions and periods of evolution. This approach depends on several factors, such as geographical location, local regulations and cultural differences, which makes it difficult to compare different LCA systems. This diversity allows the adaptation of systems to current sustainability trends for a local, regional or compartment-specific context. Here we can mention the considerable contribution of the European Union energy labels with their set of methods, solutions and investments, which are applied in the technological process to reduce energy consumption while ensuring comfort [8]. The EU target for energy efficiency and reduction of energy consumption has increased by up to 11.7% and is expected to continue to do so until 2030 [5, 6]. Studies highlight the need for energy conservation in all areas of architecture and construction, including: choosing energy-efficient equipment and using renewable energy sources. In setting this intention, architects and designers have a major impact on ensuring the energy efficiency of the building. Their mission is to seek optimal solutions to reduce energy consumption and to make heating, cooling and lighting processes more efficient by introducing renewable energy solutions without carbon emissions [9].

In the context of numerous calculation results in the field of construction, data related to interior design are also distinguished. This industry consumes a large amount of natural resources and has a strong impact on the ecology of the environment. Recognizing the pressing issue of environmental ecology and the consumption of natural resources in the process of creating a comfortable interior design, we focus our attention on sustainability rating systems for the specific segment of interior design. One such rating system is considered to be the Leadership in Energy and Environmental Design (LEED) system, as one of the most widely accepted green building certification schemes [10]. Green buildings present an optimal solution for ecological and sustainable design. The solution is energy efficient by using environmentally friendly materials. In the field of sustainability in interior design, the term and science of biomimicry is known, which is based on natural systems, which aims to imitate the efficiency and resilience of natural systems [3]. Starting from the basic building sustainability assessment systems, we identify specific interior design issues - such as material selection, indoor air quality and environmental comfort, which are included in the general building assessment compartment. Unlike construction, interior design is much more dynamic and responsive to frequent changes during the exploitation of the space. This provides ease and accessibility to the environmental performance of the space [11].

Recent research in the field addresses the issue of water conservation, which offers solutions and means to reduce water consumption through rainwater harvesting, wastewater filtration, and careful selection of sanitary fittings. Research describes ways to choose water-efficient sinks, smart faucets, and sanitary fittings that facilitate water reuse for various purposes [9]. The technical performance of these materials is evaluated by their high resistance to wear, efficient thermal and acoustic insulation and adaptation to different climatic conditions. The materials are also manifested by benefits for human health, with a reduced impact on the environment. Ecological materials, characterized by their renewable origin, reduced processing and minimal impact on the environment, represent a viable and efficient alternative to traditional materials [7, 8]. Here we can talk about sustainable materials that can be obtained by integrating remanufactured, recycled, recovered, locally

sourced, renewable or certified materials. Reconditioned materials, taken from destroyed or renovated buildings, can be used without undergoing significant modifications.

A highly promoted solution is the recycling of materials, which we can consider efficient in decomposition or recommending a new product. Recycling offers an extension of the life of materials, conserving natural resources. Recycled material can be used to produce other materials such as: steel, products such as ceiling tiles, countertops, drywall, various carpets and ceramic tiles. Renewable materials can regenerate naturally in less than 10 years. In this process, the materials provide long-term ecological benefits, saving resources for future generations. The phenomenon minimizes the impact on the natural ecosystem. Renewable materials include: bamboo, cork, cotton, hemp, etc. In interior design, materials from local sources, compatible with human life and optimal in reducing energy consumption, can be used. Local materials include a wide range of new, refurbished, recovered, recycled, renewable or certified materials, depending on their availability and the choices made by interior designers [12].

In general, the researched materials (over 20 articles) in the field of sustainability in interior design are different in terms of methodology, geographical scope and objectives, but together they contribute to completing the sustainability criteria that can be applied in contemporary interior design.

The rapid growth of industries and technologies has led to increased consumption of natural resources, which has a negative impact on the natural environment, which in turn has a negative impact on people. Modern lifestyles require many industries to mass produce technical equipment, which leads to high consumption of natural resources and devastates the natural ecosystem.

This cycle of problems can be improved through scientific and practical approaches in all fields and at all levels. In this context, the interior design industry can also be reoriented towards a trend of reducing the negative impact on the environment, opting for the promotion of living spaces that are beneficial to human health. Sustainable realization of interior design ensures the fulfillment of essential requirements in terms of ecological protection of the environment and, at the same time, encourages research into ways and solutions to improve the natural ecosystem [13]. Thus, research into the sustainability segment in interior design is absolutely necessary to achieve the possibilities of growth, improvement and performance of ecological solutions.

In the present research, several research methods were used, including the analysis and synthesis of existing information on the research topic or problem, as well as the comparative study of bibliographical sources, through which a classification of information was achieved. In this case, the theoretical comparison method was also used to more clearly assimilate the theoretical content described in the specialized literature. Throughout the work, the deduction method was also used, necessary in formulating results, decisions or findings. Through this method, it was possible to understand in stages all theoretical and practical processes in the field of Architecture and Construction, including Interior Design. It is worth mentioning that the historical-theoretical method was also approached, because the work made references to various time periods and various stages of the evolution of society. In order to look in detail at an evolutionary process manifested over a certain period of time, of course, the historical-theoretical method is very convenient.

In the process of identifying technical solutions or materials used in the study periods, the analytical method was used, which gave us the opportunity to observe, study

and conclude. This favored the optimal determination of the technical aspects of the materials used with the identification of specific parameters (region, culture and stage of evolution).

The research was carried out in several stages, initially carrying out a historical research of phenomena and evolution. Here, the temporal space parameters of the research were established, with the specific aspects of the social environment. Then the theoretical part was analyzed, which includes the classification of various techniques, methods and technologies for the practical application of materials. Also here, international energy efficiency strategies were identified with the particularities of description, identification and use.

This study had a dual vision, describing some results from both an international and national perspective, identifying traditional practices, carried out by previous generations. In the last stage, a study was developed based on the implementation of clay in the technology of interior plastic finishes, following the tradition from the beginning of the 20th century. Historical solutions are analyzed in the context of contemporary implementations, bringing proposals and recommendations for its use. This issue was also analyzed in the context of interior design with students of the Interior Design program at the Technical University of Moldova, who also conducted several simulations of the implementation of clay in plastic finishing materials.

The work used numerous scientific publications, published in specialized scientific journals. These include research both from the country (Republic of Moldova) and from abroad, carried out by researchers and scientists [14]. The category of bibliographical materials is from the field of architecture and construction, art and life sciences, so as to provide a broad vision of the subject. Historical bibliographical sources present the use of clay or clay in the construction of peasant houses, describing them as modest dwellings, built of adobe with straw, or of beams smeared with clay and lime, with a roof of shingles, or of straw, reed or reed.

3. Results and discussion

In the specialized literature, there is increasing talk about a healthy indoor environment, sustainable materials and ecological materials [15]. Given that approximately 90% of the time is spent indoors, of course, indoor air and climate, thermal, visual, acoustic and ecological comfort are of particular importance [16, 9]. Often, in the field of interior design, all these globally recognized practices are considered to belong to a style called ecological. This includes certain criteria, such as wooden furniture, stone and marble elements, linen fabrics, cotton, wool, natural fiber upholstery, ceramic objects, etc. Green solutions in interior design are in a continuous process of implementation. Therefore, green solutions in interior design are in a continuous process of implementation. Companies evaluate information on the impact of practices with the implementation of green solutions to design new products that meet society's expectations and contribute to improving the living conditions of customers [17].

In the context of green materials, there is the scope of local materials, which is a determining factor in the choice or decision regarding design solutions [18]. In each region there is a wide range of methods, technologies or materials used at various times, often put into practice by ancestors, who obtained considerable benefits from their use. Of particular importance is the resource of the regional natural environment, with its distinct particularities of soil and mineral resources [16]. According to the Institute of Pedology,

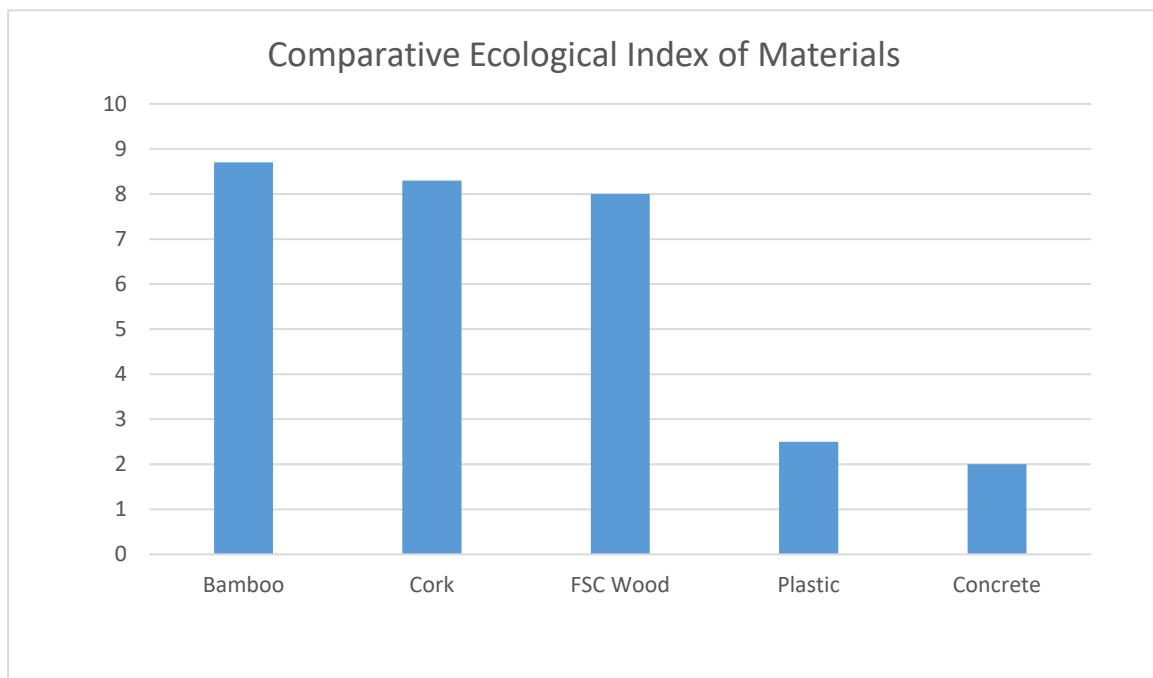
Agrochemistry and Soil Protection "Nicolae Dimo" of the Republic of Moldova [19] during the period 2009-2012 all agroecosystems studied demonstrate that the soil in the Republic of Moldova has a loamy texture, the physical clay content (< 0.01 mm) is in the range of 30-45%, varying insignificantly in all investigated ecosystems (34-36% for the depth of 0-10 cm and in the range of 33-36% for the depth of 50-60 cm).

Thus, the data show that the hygroscopic index (analytical coefficient) is directly influenced by the soil texture. In all investigated variants it corresponds to the clay texture [19].

The effectiveness of ecological materials in interior design is increasingly analyzed in research, providing data and findings that refer to their basic characteristics: they are recyclable or biodegradable; come from renewable sources; have a manufacturing process with low CO₂ emissions [15], do not contain toxic substances (formaldehyde, volatile organic compounds, etc.); are durable and reusable [20, 21]. For example: bamboo, cork, natural wool, water-based paints, natural stone, recycled glass, ecological MDF, organic textiles, etc. can demonstrate a comparative ECO-index. Table 1.

Table 1

Comparing the environmental score of building materials



Other sources speak of the Raut Valley region with clay deposits approximately 1.8 million - 10.0 thousand years old [22]. The research conducted finds a soil content with extraordinary particularities for the construction system, and these data confirm the historical construction practices known in the regions of the Romanian people. Historical bibliographic sources present the use of clay or clay in the construction of peasant houses, describing them as modest dwellings, built of adobe with straw, or of beams smeared with clay and lime, with a roof of shingles, or of straw, reed or reed. As for their constructive location, it is said that some dwellings were deeper in the ground, because in this way they kept warm in winter and cool in summer [23]. Other bibliographical sources describe the homes of Romanian-Moldovan peasants as sun-dried clay brick constructions, today welcomed as ecologically healthy homes, thanks to the eco-natural materials used [24].

The technology of blocks or so called clay "adobes" used in the construction of houses offers an effective solution in saving energy, reducing waste, reducing environmental impact and designing a healthy eco system. (Fig. 1).



Figure 1. House-museum in Butuceni village, Orheiul Vechi, Republic of Moldova.

Source: www.moldovenii.md, library. <https://www.moldovenii.md/library/photo/album/301/id/3829>

Bibliographic sources describe in detail experiences and practices from 100 years ago, when houses were built using an old technique, from raw materials that were: stone, wood and clay. According to tradition, the walls were "glued" with large pieces of clay mixed with wheat straw, kneaded well with a hoe and feet until it had a consistency similar to bread dough [24].

In the accounts of the city of Chisinau from the 15th century and the first half of the 17th century, it is described that the hut was a dwelling with a single cell, dug into the ground. The roof was built in two slopes, and its skeleton was made of rafters and wooden beams, over which the covering material was fixed: straw and reeds, covered with earth and smeared with clay. In the middle of the room was the oven with the mouth turned towards the entrance, with a chimney woven from twigs and smeared with clay. After the stove, in the inner part of the room, a clay elevation was built, used as a sleeping place for the entire family and which occupied approximately a third of the room. The old house was buried in the ground, and the floor was made of clay [25]. Clay was widely used in the interior and exterior architecture of traditional peasant houses.

Analyzing the properties of clay, we deduce important values that advocate the choice of this material, including: the ability to absorb and release moisture; balancing the indoor climate; absorbing and neutralizing pathogens; accumulating and maintaining heat; saving energy and reducing environmental pollution; reusability; low cost; ease of use and others. Among the disadvantages, we mention the fact that clay is subject to biological degradation, which requires good ventilation during construction so that clay surfaces dry quickly. During drying, cracks or fissures may appear that must be carefully filled after drying. Also, the clay mixture shrinks when it dries, and in this case, moisture is needed to activate the binding power and for better malleability [26]. Clay shrinkage can be limited by reducing the clay and water content, optimizing the distribution of granules and using additives [27].

The use of clay in construction is not an invention of a single people, but a practice of several countries and regions. For example, in France, the technique of compacted clay, called "terre pisé", has been widely used since the 15th century; in Germany, old houses made of compacted clay are known, dating back to 1795; and in Western Europe, the advantages of clay for creating comfortable living conditions have been appreciated [20, 18]. Thus, several researchers have argued that houses that have clay as the main building material have a characteristic or particular exterior appearance, with a freedom of plastic modeling [15, 23]. Signaling some parallels with other cities from the 17th century, found in some documentary sources about the city of Chisinau, regarding the material from which the houses were built, wood was the basic material, then gluing the walls was present in the construction techniques, the poorest houses were covered with straw, the best material was reed, used for the roofs of the houses, shingles were a more precious and expensive material [25]. (Fig. 2 a,b,c,d,e,f).



Figure 2. Concept projects of interiors in traditional style with the implementation of ecological materials (a,b,c,d,e,f).

Source: collage of traditional elements in the interior, made by student Bortova Daria of the Interior Design program of the Technical University of Moldova.

According to current research, the construction industry is increasingly concerned about the problem of environmental pollution, seeking solutions to reduce gas emissions and raw material consumption [25, 27]. The concerns of manufacturers of finishing materials include trends in the creation of water-diluted resins; solutions for increasing the adhesion performance of materials to the substrate; the creation of different types of silicone paints; the coexistence of organic and inorganic products; the creation of crosslinking applications under the action of radiation; the creation of coatings designed to save energy and resources, and others. In search of a solution to the existing ecological problem, an important solution would be to return to natural raw materials, verified and practiced many generations ago.

According to M. Miron & V. Miron (2021) [25] it was found that the evolution of housing types in the Chisinau locality was specific by approaching the constructive systems and materials from the country's stone rocks. In the research of Agiurre et al., (2022) [21] more general geoclimatic aspects are analyzed. The researcher mentions the problem of global warming as a consequence of the pollution of the natural environment and the depletion of resources. The idea promoted in this material refers to the advantages of eco materials, especially clay, both for conserving natural resources and for stopping climate degradation. The use of clay in interior finishes is possible due to the fact that the earth's natural ecosystem is always in a process of forming clay layers and these can be an unlimited resource in generating construction materials.

Eco-friendly materials tend to bring a very convenient solution both in terms of conserving natural resources and stopping climate degradation. The hypothesis is due to the fact that the natural and natural process of forming clay layers provides an unlimited resource in generating the given material for construction.

In the context of scientific analyses, the authors Spreafico & Landi, (2022) [17], Utama et al., (2022) [15] consider that there is a need to create hybrid manufactures to provide all the materials needed for construction. The authors present the achievements obtained in previous scientific works, explaining their benefits and opportunities. The results are associated with the solutions proposed in this work, in particular through products obtained from clay, which have all the properties of the natural material [26]. Also, the strength and durability obtained through lightweight combinations with harder or sustainable materials bring considerable benefits. In the research works of specialists in agriculture and soil ecology, such as Andriuca et al., (2023) [19], the possible problems of soil degradation following geoclimatic changes are discussed. One of the reasons for this phenomenon may be the decrease in ecological norms and their consequences. In this context, the most active use of clay as a raw material in the creation of techniques or technologies for finishing plastic materials becomes opportune in stopping the pollution of the natural environment, and this fact favors the achievement of normal life cycles of ecological materials.

The studies and discussions presented create an overview of eco-efficiency methods through materials used in interior design. Scientific research describes and introduces sustainable techniques and technologies, renewable materials and resources in the creation of interior design [10, 17] and following some general deductions, new solutions with benefits that improve the living environment are highlighted. These are the use of natural resources that are abundant in the lands of the Republic of Moldova and neighboring countries, low material costs, ease of use and most importantly, ecological effects on

people's life and health. The deductions made in this study complement the information field with solutions and experiences previously practiced in the construction sector. The use of local materials was a very well-known practice 50-100 years ago. The given solutions can be brought back to the construction and interior design industry as an optimal way to increase the energy efficiency of homes, increase the ecological ambiance of interiors and reduce toxic residues.

Based on the previous practice of using clay in house construction, known from numerous bibliographic sources, the benefits and advantages offered by the material can be determined, based on past favorable experiences in making decisions about its use [24, 26]. Among the Advantages of eco materials are: protecting and improving the environment; positive impact on the psychological state; the presence of minimalism; lower heating costs; easier dismantling and increased recycling potential; durability, functionality and efficiency. Among the disadvantages are: expensive materials; expenses and difficulties in repair; competition with cheap synthetic materials; difficulties in cleaning and maintenance. The peculiarities of eco-design are classified according to technical and aesthetic qualities that can be used depending on the type and category of rooms. Previous practices in the use of eco materials have a positive impact on the restoration of the natural ecosystem and the improvement of the human living environment [25]. Due to its benefits, clay and clay-based products have gained great importance in the current living environment as a solution to solve and maintain the natural ecosystem.

5. Conclusions

As a result, the conclusions of the study provide an insight into the most effective practices in the use of ecological materials for sustainable interior design and specifically for the use of clay in interior finishing materials. The benefits of clay were listed, which consist of: the availability of this natural resource in many regions of the world, the positive effect on energy efficiency, ensuring a very good ecological climate in the interior space and a return to old practices through new uses of clay. The favorable properties of clay were identified through actions of cleaning and protecting the natural ecosystem; ecological purification, decarbonization of the environment and ensuring an optimal climate inside homes. From a chemical point of view, it was found that clay can be adapted to various techniques and technologies of combination in the formation of alloys for interior and exterior finishes. Their composition has the ability to maintain a close connection with nature and the natural ecological environment.

The scientific material has opened new perspectives for further research in the development of optimal strategies for creating new techniques and technologies of plastic interior finishing materials with clay content. Clay-based products have demonstrated extraordinary capabilities in ensuring a healthy indoor environment, effective in solving many environmental problems due to climate change. The recommended solution completes the scope of interior finishing technologies and expands the possibilities for further development of comfort in interior design.

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