Vol 4, 1 (2018) 20-25

Contents lists available at Article URL

KKU Journal of Basic and Applied Sciences

Journal homepage: jbas.kku.edu.sa

Validating the Significance of Nano-Bio Materials for Sustainability: A Case of Flooring Maintenance Materials

Mohammed A. M. Alhefnawi [a]

[a] Department of Architecture, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, Dammam

Received: May 2018 / Revised: July 2018 / Accepted: December 2018 / Published: 25 December 2018

Abstract: Nanoarchitecture opens new possibilities in building sustainability, it prompts environmental and zero carbon design and delivers new materials which can meet natural execution criteria and impacts of climatic change. The vast majority of present building and engineering concepts are to substitute numerous petrochemically derivatives with bio-based materials from sustainable assets. Scientists endure to achieve progress and defeat the cost of processing plant material into value-added products. The paper brought up the issue of: In the era of developments and blasting of new ideas, for example, sustainability and Nano materials-; Are buildings' maintenance materials and applications anticipated that would react to current advancements? The paper acquainted a connected idea with bio-based and Nano models for the maintenance of building floors. The point was to approve the added value to sustainability that a bio Nano maintenance material can offer better than a traditional chemically produced one. A comparative analysis was carried out for the Nano green mastic remover, and Bean-e-doo mastic remover. The analysis covered the relative performance of both materials in respect to environmental and economic criteria. The comparison was carried out in an online platform using the BEES software. Results demonstrated that the Nano-Green material has less ecological effects, as well as less introductory and future financial expenses too contrasted with the Bean-e-doo mastic remover material. Consequently, the linkage between Bio based and Nano materials on one hand, and sustainable maintenance on the other hand is unmistakably distinguished.

Keywords: Bean-e-doo; Bio-based; Life cycle impacts; Mastic remover; Nano materials; Sustainable maintenance.

1. INTRODUCTION

previous two decades. Spending on nanotechnology investigations is substantial; though, the research is incessantly moving forward inspired by instant gainful revenues engendered by high value marketable products [1]. Efforts are made at the global level, especially at European level, to include Nano materials in all economic fields [2]. Nanomaterials have the size of its single unit between 1 and 1000 nanometers (10^{-9} meter). The usual definition of nanoscale is between 1 and 100 nm. [3] Nano scale materials have their unique optical, electronic, or mechanical properties. [4] They are gradually commercialized [5] starting to develop as supplies [6], expressively fixing existing construction difficulties [1], and resolve problems associated with energy production and consumption in building, or water treatment and air purification [7]. Furthermore, they may alter the settings and organization of building process [1].

It is easily accepted that bio-based products are more preferred than fossil fuel-based products. It looks reasonable that it is more sustainable to utilize resources which are grown in sustainable practices. Bio-based products are portions of the natural cycles on Earth, while fossil fuel-based products disturb the ecosystems [8]. So that, current developments are rising the scenarios of substituting many petrochemically derivatives with materials processed from renewable resources. Scientists endure to achieve progress and defeat the cost of processing plant material into value-added products. At the same time, environmental worries and regulation are increasing the attention in agricultural and forestry resources as a

Correspondence:
E-mail: malhefnawi@iau.edu.sa
Tel: o*******

substitute feedstock [9]. Many studies on maintenance approaches and techniques advice that the use of bio-based products is much more environmentally friendly compared to fossil fuel-based maintenance products [10]. Though, it's significant to recognize that bio-based materials can result in substantial adverse effects [8]. Furthermore, successful maintenance should not only focus on extending the life span of buildings and reducing its operational costs, ecosystem impacts, and wellbeing should get enough consideration in this respect [11].

Biomimicry is defined as novelty concluded from the emulation of biological structures, processes, shapes, and schemes [12]. Many environmentally friendly products are produced adopting the concept of biomimicry [13]. The 2005 World Summit defined the goals of sustainability in the form of economic and social development, and environmental protection [14], [15]. The approach articulated the three pillars of sustainability using three overlapping interdependent ellipses [16], [17], [18]. Which serve as a mutual base for plentiful sustainability morals [19], [20]. Some experts added a fourth pillar to sustainability and assigned it to future generation [21]. Some others reflected resource use and economic sustainability as two supplementary pillars [22]. More recently, the Circles of Sustainability approach classified four areas of economic, ecological, political and cultural sustainability, which got in harmony with the Agenda 21 of the United Nations [23], that stipulates culture as the fourth area of sustainable development, Fig.1. [24] The model is now being adopted by societies such as the United Nations Cities Programme and Metropolis [25].

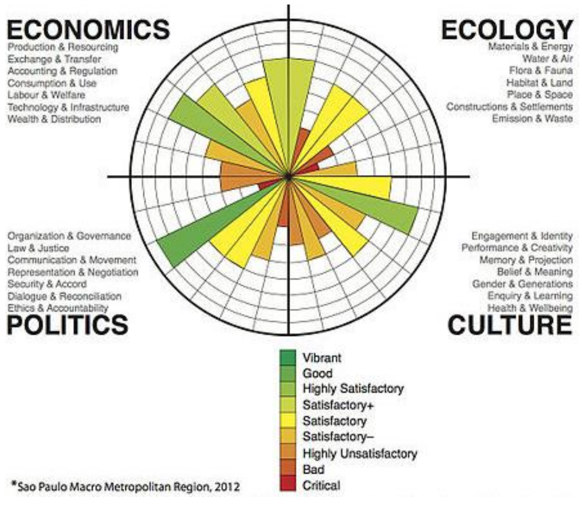

Figure. 1. Sao Paulo Circles of sustainability [25]

There are many studies handled the innovative approaches related to utilizing Nano and bionic materials in the field of building and maintenance.

Ge and Gao [1] documented competitive nanotechnology innovations in construction industry. The applications generally serve in the aspects of lighter and more durable composites, more efficient fire retardant and thermal insulators, Nano-sensors, and low maintenance coating. TiO_2 is used to coat glazing for its sterilizing and anti-fouling properties. The TiO_2 breaks down organic dirt and allows water to spread over the surface and wash away dirt. Berevoescu [2] presented an analytical comparative application of using nanogels and polystyrene as thermal insulation materials in two-storey building from the view of performance and cost. The application demonstrated that the nanogel option is initially expensive but has more advantageous, considering the long run low costs because of reduced energy consumption.

Nature-fibers insulation materials, which are used in the forms of blow injection fills and panels, although their thermal insulation efficiencies are less than polystyrene, they are closer to the efficiencies of glass wool, stone wool, foam glass, and Perlite [26].

Biological fibers in composite materials, foam fiber composite (FFC), manufactured by Friul Filiere SPA that developed an ultra-light PVC wood composite material which can be processed like wood. It is 100% recyclable and has very good mechanical and physical qualities: Stability, moisture resistance, elasticity, heat and sound insulation, relatively cheap, and self-deleting in fire [27]. Bio-based Almond polymer degradable materials are employed as a coating material in the furniture industry. Furthermore, fungi can provide strong bonds between vegetable waste-based materials as a substitute of Styrofoam [28]. Flax, hemp, kenaf, sisal or abaca are combined to produce Nature Fiber Reinforced Plastics (NFP). The production of these modern materials requires binders such as animal and vegetable adhesives, glues and resins. Nature fiber reinforced composite materials have the good qualities of both raw materials of wood and plastic. They are sustainable, up to 100% CO_2-neutral, 100% biodegradable, hygienic materials, high shock absorption, good impact resistant, low weight, and tough [29]. The paper demonstrated the possibility of incorporating Nano bio materials into building maintenance to reduce the environmental and economic burdens. Which set a motivation for further research on new concepts to correspond with the era of innovations in building materials

2. METHODOLOGY

The objective of the paper was to validate the linkage between Nano materials, bio-based material and sustainability. To achieve this objective, an aim was set to examine the efficiency of two different materials, Nano green mastic remover (also known as Agri Nano which is extracted from agricultural sources) and Bean-e-doo mastic remover (which has a chemical base), regarding their environmental and economic performance as two different maintenance materials in BEES. BEES software is a useful technique developed by the National Institute of Standards and Technology Engineering Laboratory's, it uses the life-cycle assessment approach to measure the environmental performance of building products [30]. All phases of the life of a product are analyzed as of the ISO 14040 series: raw material, production, transport, fixing, usage, and reprocessing and left-over managing. Economic performance is measured using life-cycle cost technique, which covers the of initial costs, replacement, process, maintenance and repair, and disposal. Environmental and economic performance are joint into a total performance measure using the ASTM standard for Multi-Attribute Decision Analysis.

II.1. Materials Descriptions

II.1.1 Nano Green mastic remover

Nano Green mastic remover is bio based and biodegradable food stocks, principally corn, grains, soybeans, and potatoes. Its cleaning ability is as effective as many detergents. The purpose of mastic remover is to remove 9.29 m2 of mastic under vinyl or similar flooring. The flow diagram below shows the major elements of the production of Nano Fig. 2. Energy is used in the production of Nano Green to mix the product. All materials are transported by diesel truck approximately 805 km to the factory, and to the building sites afterwards. Around 0.002 m3 of the mastic remover is required to eradicate 18.6 m2 of mastic under the flooring material. It is expected that Nano Green is applied twice to eliminate mastic over a period of 50 years [31].

II.1.2 Been-e-doo mastic remover

1.1.1

Produced from soybeans, BEAN-e-doo is a chief remover intended to diminish any mastic cement on solid surfaces. It is perfect for use in working spaces like schools, healing facilities, post offices, and other open spots without disturbances. It has under 3% VOC's, Light Yellow, low viscosity liquid, low dissipation rates, PH = 6.65, Specific gravity less than 1, mild odor, non-Flammable, simple tidy up and workers saver, removes up to 92.9 sq. meters (1000 sq. ft.) per 5 gallons [32].

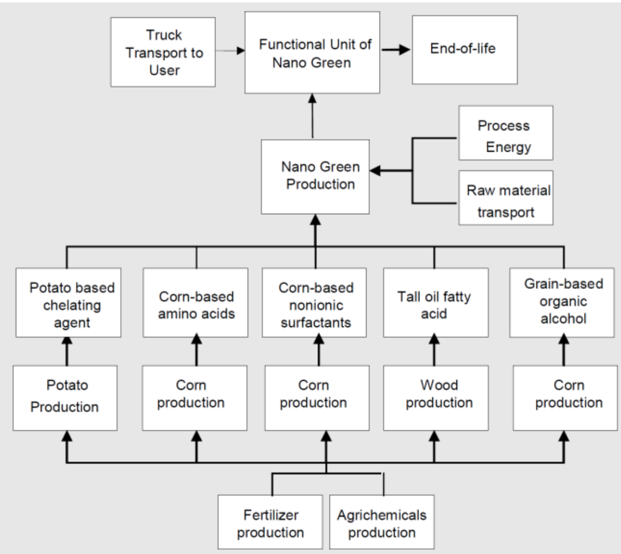

Figure. 2. Nano Green System Boundaries [31]

II.2. Analysis Parameters

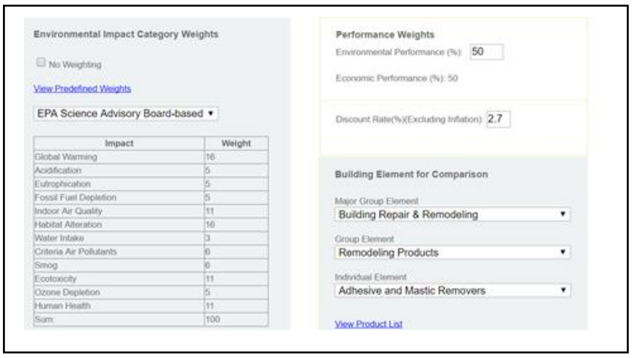

Figure. 3. Screen shot of the BEES interface showing the analysis parameters chosen

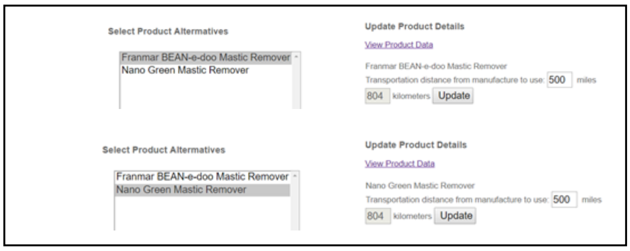

Figure. 4. Selection of the alternatives

3. RESULTS AND DISCUSSION

Illustrated below are the outcomes of the comparative analysis of sustainability performance of Nano Green and Bean-e-doo mastic removers

III.1. Summary analysis

From figures 5,6, and 7; it is noticed that Nano Green mastic remover is more economic and environmentally efficient compared to Bean-e-doo. The economic present value (PV) of Nano Green mastic remover is almost half of the corresponding value of Bean-e-doo. Furthermore, the hazardous environmental effects of the Nano Green mastic remover are very limited and equal to almost 18% Pts/unit compared to Bean-e-doo.

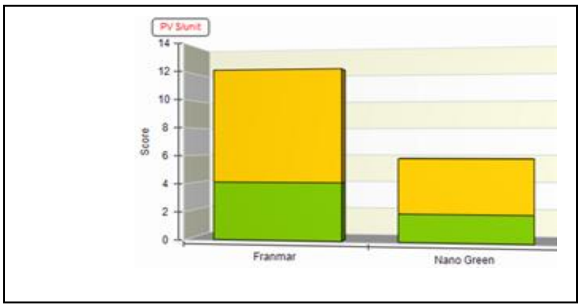

Figure. 5. Economic performance

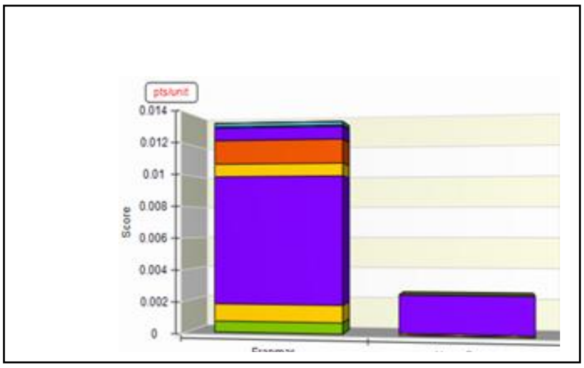

Figure. 6. Environmental performance

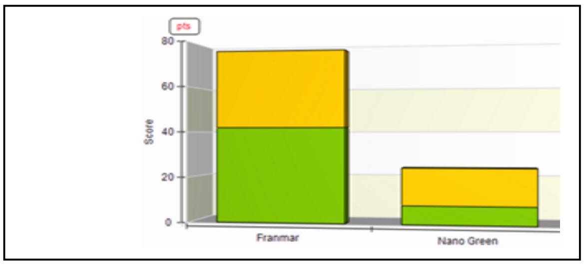

Figure. 7. Overall performance

III.2. Life cycle stage graphs

Figures 8,9,10,11,12, and 13 show that Green mastic remover is very environmentally preferred in all its life cycle phases from raw materials, manufacturing, transportation, use, and disposal. Nano Green mastic remover generally has less adverse impacts that vary between (1% to 30%) compared to Bean-e-doo as illustrated and indicated in brackets as follows: Environmental performance (19%), fusil fuel depletion (1%), indoor air quality (30%), water intake (7%), human health cancer (27%), and finally human health none-cancer (2.8%).

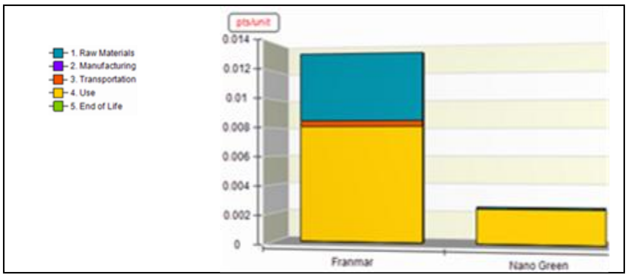

Figure. 8. Environmental performance

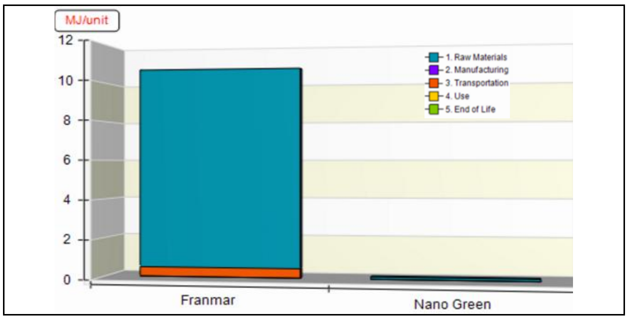

Figure. 9. Fusil fuel depletion

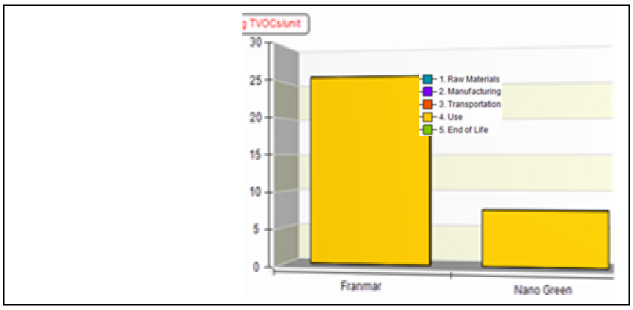

Figure. 10. Indoor air quality

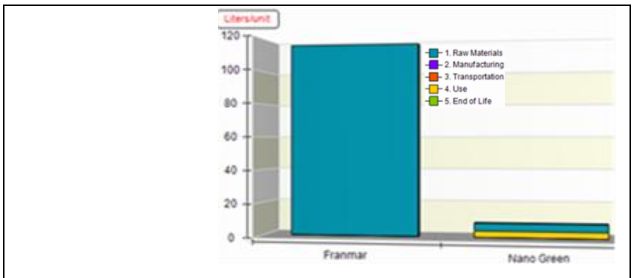

Figure. 11. Water intake

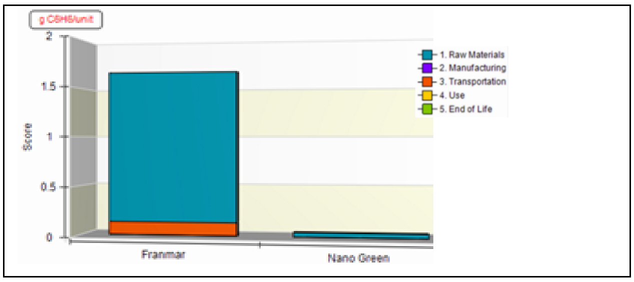

Figure. 12. Human health cancer

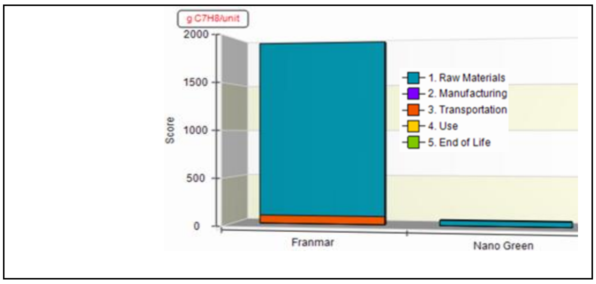

Figure. 13. Human health non-cancer

III.3. Environmental flow analysis

Figures 14,15, and 16 exemplify that Green mastic remover is a very good environmentally friendly option. The global warming impacts resulted from Green Mastic remover records only (-7.4632 gCo2/unit) compared to 1265.4648 gCo2 for Bean-e-doo. Furthermore, it has limited adverse environmental impacts compared to Bean-e-doo as illustrated above and indicated between brackets: acidification (3.9%), and eutrophication (6.3%).

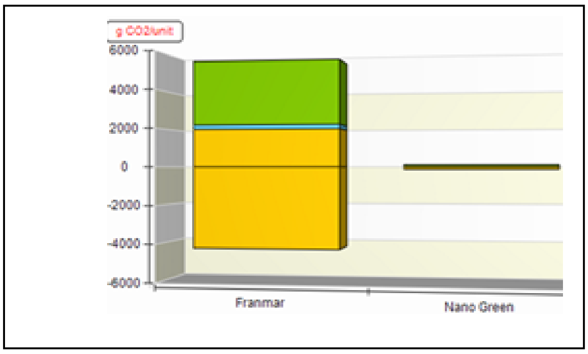

Figure. 14. Global warming

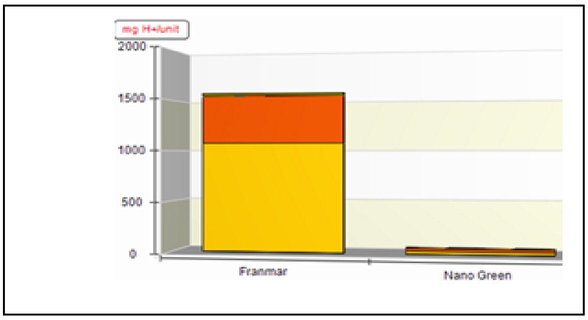

Figure. 15. Acidification

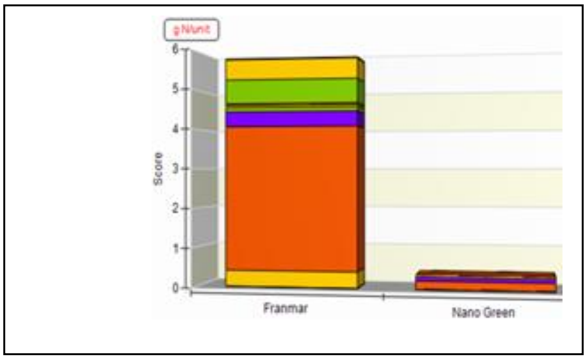

Figure. 16. Eutrophication

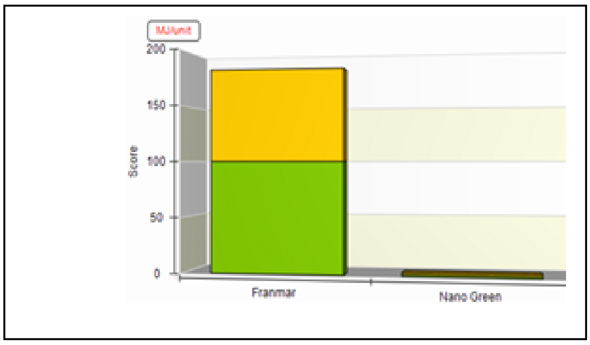

Figure. 17. Embodied energy by fuel renewal

III.4. Embodied energy analysis

Figures 17, and 18 prove that Green mastic remover has a very low quantity of embodied energy compared to Bean-e-doo. Embodied energy consumption from renewable or non-renewable energy sources in the production and processing of Nano Green mastic remover is very limited and falls to around 1.7% compared to Bea-e-doo.

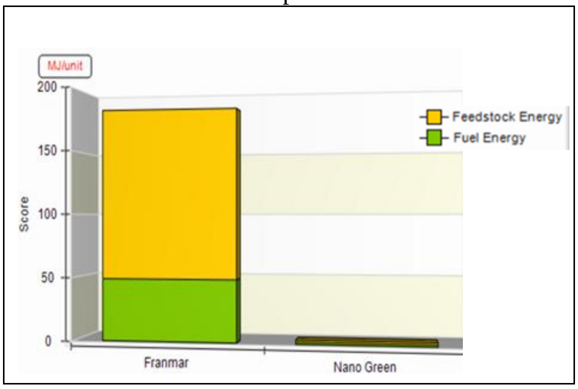

Figure. 18. Embodied energy by fuel usage

Results prove that Nano Green mastic remover has less environmental impacts and less initial and future economic costs compared to Bean-e-doo mastic remover. It may be rational to justify the lower environmental impacts of bio-based materials compared to chemically produced one. Bio-based matter is a portion of a series in the ecosystem. It absorbs carbon dioxide from the atmosphere during its growth phase, in photosynthesis, and reduces its concentration in the atmosphere. It also re-releases carbon dioxide in the atmosphere during plant breathing, and when being consumed or converted into organic waste. So that, they are considered neutral for their climate impacts. Therefore, we note that the negative environmental impacts of Nano-Green mastic remover within the results of this paper, in respect to life cycle analysis- fossil fuel depletion, indoor air quality, water intake, human health, global warming, acidification, eutrophication, and embodied energy- came far less than the equivalent impacts of the chemically based mastic remover.

In terms of economics, bio-based material is often produced from organic waste, which is naturally available at low or no cost as agricultural products such as cane, wheat, rice, potatoes and other crops. Thus, its costs in its initial and later stages are less expensive than chemically manufactured materials, which require financial investments, technology, more skilled and trained workers, factories, transport, and environmental treatments if any. These factors raise the economic cost of producing such materials, and thus raise their prices compared to bio-based products.

Though, it's significant to recognize that bio-based materials can result in substantial adverse environmental effects. As biomass production requires the use of fertilizers, and sometimes pesticides, which emit harmful gases. Fertilizers are produced from fossil fuels, there is also an impact related to the change of land use pattern to produce more biomass which competes with the lands assigned for food production. Therefore, bio-based materials cannot be considered of better than others on the absolute. Each case should be studied separately through the whole life cycle of the material to be considered more environmentally friendly or not than others.

4. CONCLUSION

The linkage between bio-based and Nano materials on one hand, and sustainable or green maintenance on the other hand is clearly identified. Consequently, incorporating bio-based and Nano materials into building industry might reduce downsides of using fossil fuel-based maintenance materials and enhance our environmental and economic conditions.

RECOMMENDATION

Advanced researches on bio-based materials and Nano technology should be encouraged in research institutions and manufacturing organizations to seek more sustainable communities. More improvement should be directed to add more alternatives of materials, considering the variations of different tools and production methods and extraction in different countries.

REFERENCES

[1] Ge, Z., and Gao, Z. (2008), **"Applications of Nanotechnology and Nanomaterials in Construction, First International Conference on Construction in Developing Countries (ICCIDC–I)"**, Advancing and Integrating Construction Education, Research & Practice, August 4-5, 2008, Karachi, Pakistan. Pp. 235-240.

[2] Berevoescu, L., Stoian, V., and Dan, D. (2009), **"Aerogel – A Performant Nanomaterial for Sustainable Buildings"**, Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering, pp. 457-462

[3] Buzea, C., Pacheco, I., and Robbie, K. (2007), **"Nanomaterials and Nanoparticles: Sources and Toxicity"**,

Biointerphases. 2 (4): MR17–MR71. PMID 20419892. doi:10.1116/1.2815690.

[4] Hubler, A. and Osuagwu, O. (2010), "**Digital Quantum Batteries: Energy and Information Storage in Nanovacuum Tube Arrays**", Complexity. doi:10.1002/cplx.20306.

[5] Eldridge, T. (2014), "**Achieving Industry Integration with Nanomaterials Through Financial Markets**", Nanotechnology Now.

[6] McGovern, C. (2010), "**Commoditization of Nanomaterials**", Nanotechnol. Perceptions. 6 (3): 155–178. doi: 10.4024/N15GO10A.ntp.06.03

[7] Fouad, F. F. and Ibrahim, M. A. (2013), "**Nano Archirecture and Sustainability**", Advanced Materials Research, Vols. 671-674, pp. 2298-2303.

[8] Contreras, S. (2018), "**Bio-based Products Are Always Better Than Fossil Fuel-based Products: Myth Or Not?**", https://www.pre-sustainability.com/news/bio-based-products-are-always-good-myth-or-not. Accessed on 21/9/2019.

[9] The National Academy of Sciences (2000), https://www.ncbi.nlm.nih.gov/books/NBK232957, acceded 18/9/2018.

[10] Elghaffar, MAEM (2007), "**A Practical Guide for School Buildings Maintenance**", Assiut University Bulletin for Environmental Researches, 10 (1), 59-71.

[11] Elghaffar, MAEM (2007), "**Life-cycle Assessment Tools for Maintenance Management and Resource Conservation**", Assiut University Bulletin for Environmental Researches, 10 (1), 73-83.

[12] Kennedy, E. B., and Marting, T. A. (2016), "**Biomimicry Streamlining the Front End of Innovation for Environmentally Sustainable Products**", Research-Technology Management, Biomimicry. pp 40-47.

[13] Vincent, J. F. V., Bogatyreva, O. A., Bogatyrev, N. R., Bowyer, A., and Pahl, A.-K. (2006), "**Biomimetics—its practice and theory**", Journal of the Royal Society Interface. 3 (9): 471–482. PMC 1664643. PMID 16849244. doi:10.1098/rsif.2006.0127.

[14] Alhefnawi, M. and AlQahtany, M. (2017), "**Thermal Insulation Efficiency of Unventilated Air-Gapped Facades in Hot Climate**", Arabian Journal for Science and Engineering. 42 (3), 1155-1160. SPRINGER Publishing.

[15] United Nations General Assembly (2005), "**2005 World Summit Outcome**", Resolution A/60/1, adopted by the General Assembly on 15 September 2005. Accessed on 17/3/2018.

[16] Alhefnawi, M. (2014), "**Sustainability Issues Awareness: A Case Study in Dammam University**", King Saud Journal of Architecture & Planning, 26 (1)

[17] Forestry Commission of Great Britain. "**Sustainability**", Accessed on: 12/4/2018

[18] Morelli, J. (2011), "**Environmental Sustainability: A Definition for Environmental Professionals**", Journal of Environmental Sustainability -Volume 1. Rochester Institute of Technology.

[19] Manning, S., Boons, F., Von Hagen, O., and Reinecke, J. (2011), "**National Contexts Matter: The Co-Evolution of Sustainability Standards in Global Value Chains**", Ecological Economics, Forthcoming.

[20] Reinecke, J., Manning, S., and Von Hagen, O. (2012), "**The Emergence of a Standards Market: Multiplicity of Sustainability Standards in the Global Coffee Industry**", Organization Studies, Forthcoming.

[21] SURF Framework for a Sustainable Economy (2013), Journal of Management and Sustainability. Accessed 23/7/208.

[22] Dhakal, K. P., Oh, J. S. T, and DI Congress (2011), "**American Society of Civil Engineers**", pp. 987–996. ISBN 9780784411674. doi:10.1061/41167(398)94.

[23] Abdelgaffar, MA (2012), "**Assessing Sustainability Indicators of a Commercial Building: A LEED Approach**", King Abdelaziz University Journal of Environmental Design and Science, 6 (1), 83-108

[24] United Cites and Local Governments, "**Culture: Fourth Pillar of Sustainable Development".**

[25] "**Circles of Sustainability**". http://citiesprogramme.com. Accessed on 12/7/2018.

[26] James, P., Magee, L., Scerri, A., and Steger, M., (2015), "**Urban Sustainability in Theory and Practice**", Routledge Tylor and Francis Group, London, Ney York.

[27] Zitate N. S., T. (2011), "**Bionik: Ideenquelle und Anregungen für Dämmmaterialien",** Kongress Nanotechnik und Bionik – Hightech in der Bauwirtschaft. 18.11.2011, München. – Bildquelle: Blum R., Labor Blum.

[28] www.materialica.de/html/pvc.html: Ultraleichtes PVC-Verbundmaterial aus Italien auf dem Deutschen Markt. – http://www.interempresas.net/Plastics/Articles/43806-The-represented-Imvolcashow- their-latest-products-in-the-2010-K.html. Accessed on 20/9/2018.

[29] Peters, S. (2011), "**Material revolution. Nachhaltige und multifunktionelle Materialien für Design und Architektur**", Birkhäuser, Basel. Zum Thema: Abschnitt „Biobasierte Materialien", S. 30–59.

[30] Information Stand (2012), jakob-winter.com bzw. www.naturfaserverbundwerkstoffe.de/de. – S. auch www.wpc-kongress.de – www.nachwachsende-rohstoffe.info und www.nova-institut.de/bio. Accessed on 21/7/2018.