I J R B A T, Issue (XIV) Volume (I) Jan 2026: 23-31 e-ISSN 2347 – 517X

A Double-Blind Peer Reviewed & Refereed Journal OPEN ACCESS Review Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

 www.ijrbat.in

A REVIEW OF RECENT STUDIES ON ECO-FRIENDLY DETERGENT FORMULATIONS

Priyadarshini P. Chahande[1], Nikeeta Chahande[2], Priyanka Ramteke[3], Hardik Siriah[4]
[1,3] Sevadal Mahila Mahavidyalaya, Nagpur, Maharashtra
[2]Independent researcher
[4]Independent researcher
priyadarshinichahande@gmail.com

Communicated: 25.10.2025	Revision: 28.10.2025 & 15.11.2025 Accepted: 25.11.2025	Published: 30.01.2026

ABSTRACT:
The widespread use of synthetic surfactants in household and industrial detergents has raised concerns due to their several potential health and environmental impacts like aquatic toxicity and degradability issues. Over the years, there has been a rising interest towards natural and sustainable materials, and hence the demand for eco-friendly detergents has also increased. Customer awareness, prioritization of health especially after the pandemic and the need for companies to meet environmental targets have collectively created a demand for eco-friendly materials including detergents. In response, immense research has been conducted to explore the potential of naturally derived alternatives that are sourced from plants, animals, and microbes. This review offers a summary of some recent studies which have explored the potential of eco-friendly materials for their detergent properties. This paper synthesizes its findings from the recent experimental studies that have tested the ability of natural materials for their detergent properties. The article has reviewed studies that tested natural detergent formulations, compared environmental impacts of synthetic vs natural detergents, identified plant-based metabolites with surface active properties and have discussed the key constraints in the adoption of natural detergents. Our review indicates that there are multiple natural materials that can provide promising cleaning and surface-active functions. Limitations remain in terms of scalability, standardization, and further toxicity assessments for their real-world applicability.

Keywords:- *Natural surfactants, biobased detergents, biosurfactants, eco-friendly detergents, environment.*

INTRODUCTION:

India is one of the largest producers of detergents in the world. In 2024, the size of the Indian market detergents reached USD 4.79 Billion, and it is expected to reach USD 7.30 Billion by 2033 [Imarcgroup.com, 2025]. The major reasons for the rapid expansion of the market are- increased urbanization, and the rising need for liquid detergents and eco-friendly detergents [Imarcgroup.com, 2025].

A good cleaning process should be a combination of various factors including chemical, mechanical, thermal effects along with time. Detergents help create this power in a washing process [Sülar et al., 2024; Ali A et al., 2018]. The word 'Surfactants' stands for surface active agents that have the dual properties of hydrophobicity and hydrophilicity. Surfactants are also called as amphiphiles or tensides. The polar part has a tendency towards water whereas the apolar part tends to be attracted towards oil [Dave & Joshi, 2017; Shinoda K., 1967; Garrett, H. E., 1972; Rosen, M. J., 1978; Schott, H.,1985]. When in aqueous solution, surfactants fundamentally can form aggregates called micelles that have both polar and non-polar regions [Dave & Joshi, 2017; Holmberg et al., 2002]. It is these micelles that in aqueous solutions affect the solubility of organic hydrocarbons and oils [Dave & Joshi, 2017]. In general, surfactants are known for increasing the cleansing power of water by reducing its surface tension, which makes them a common component of household detergents and cleaning products [Rai et al., 2021; García-Becerra, Allen and Acosta, 2010]. The applications of detergents can be seen in oilfield chemicals, agricultural chemicals, pharmaceuticals, textiles,

http://doi.org/10.29369/ijrbat.2026.010.1.0004

and polymerization of emulsions which are used in cosmetics, personal care products, food, and paper processing [Rai et al., 2021; Sparg, Light and van Staden, 2004; Vincken et al., 2007]. Today, the Indian soap and cleaning agents industry holds a prominent share in the country's Fast-Moving Consumer Goods (FMCG) sector. The industry has seen a transformation from being just a commodity segment into a competitive sector. Once seen as a luxury product, they are now seen in every household of the country. In the current times, the industry is seen to have a dynamic influence by consumer preferences and is highly dictated by brand loyalty [Gunjal and Amin, 2025].

The history of soaps and detergents in India portrays a long-standing reliance on locally available and natural plant and mineral based resources for the everyday utensil, clothes and general cleaning practices [Aruna Jyothi Kora, 2024; Lawagon and Amon, 2019]. Bio-based cleaning practices and dependence on natural dishwashing materials have been embedded in the domestic life in the country since centuries. Aruna Jyothi Kora, 2024; have discussed that natural dish wash cleaning materials can be classified into the following types based on their texture, application, and mechanism of action: a) **Scrubbers and scrappers:** These are naturally based plant material which have rough surfaces- ideal for cleaning purpose. The process of scrubbing involves physical action for the removal of dirt and dust. Examples of such materials include- paddy straw, bagasse, coconut coir, rice straw, and even animal materials like calcareous shells. b) **Abrasives:** These work by action of abrasion which is used for removing of dirt and stains from kitchen utensils [Aruna Jyothi Kora, 2024]. These include materials like soil, clay, and sand. Lime is very known abrasive which is used for soot, tar, grease and stain removal from glass, chimney, and silverware due to its alkaline and abrasive nature[Aruna Jyothi Kora, 2024; YK Murthy, 2014]. Again, Multani mitti is a very common traditionally used type of abrasive for intensive cleaning [Aruna Jyothi Kora, 2024]. Because it has high oil absorption properties, Multani mitti is commonly used for cleaning greasy and oily kitchenware [Aruna Jyothi Kora, 2024]. c) **Degreasers:** These materials contain natural organic acids that can dissolve grease, tough stains, mineral deposits and removes the odour from the clay, aluminium, stainless steel, copper, brass, and silver kitchenware [Aruna Jyothi Kora, 2024]. It acts as an emulsifier degreaser which break down the dirt or stain. d) **Deodorizers:** It can be defined as a substance or device used to remove, mask, or absorb unpleasant odours from something [Aruna Jyothi Kora, 2024, Srinivasan, 2019]. Citrus fruit peels can be used to remove the odour from kitchenware. This is because citrus peels impart pleasant smell and have flavonoids, saponins, antimicrobial essential oil with organic acids [Aruna Jyothi Kora, 2024].

2.C Harmful effects of the non-renewable based surfactants on Environment and Health*:*

The major benefit of natural dishwashers is that they cause no microplastic contamination, when compared to plastic scrubbers [Aruna Jyothi Kora, 2024; Kora, 2019]. Natural dishwash cleaners also do not release any phosphate in the water bodies and thus there is no danger of eutrophication [Aruna Jyothi Kora, 2024; Kora, A.J. et al., 2017; Van Hoof, Fan and Lievens, 2017; Tusseau-Vuillemin, 2001]. The most useful properties of natural dishwashers are- easily natural availability, renewability, low cost, simple extraction, superior stability at changeable conditions, low critical micellar concentration value, biodegradability under aerobic and anaerobic conditions, non-/hypo-human allergenicity, hand biocompatibility, low human and animal toxicity, multifaceted biological activities [Aruna Jyothi Kora, 2024; Greenmoksha, 2015; Le Guenic et al., 2018; Waran and Chandran, 2021]. Unlike their counterparts, they are also not dependent on fossil fuels, and hence

http://doi.org/10.29369/ijrbat.2026.010.1.0004

cause no greenhouse gas emission, no air and water pollution, and have a lower carbon footprint [Aruna Jyothi Kora, 2024; Wisetkomolmat et al., 2021]. Overall, natural dishwashers offer several advantages that make them a more sustainable option than the conventional synthetic/manmade formulations.

2.C Harmful effects of the non-renewable based surfactants on Environment and Health:

Surfactants derived from non-renewable sources can pose serious damages mainly because they are highly toxic and have less biodegradability and thus are a burden to the environment [Romero Vega and Gallo Stampino, 2025; Agger, J. W., and Zeuner, B., 2022]. Side effects of the left laundry chemicals in textiles include-toxicity and irritation of the skin, eyes, and respiratory system [Gupta and Sekhri, 2021]. When it comes to the effects on environment, the impact caused largely depends upon nature and the chemical properties of the ingredients in the detergent formulations. It also depends upon the quantities of the detergent used for the washing process [Gupta and Sekhri, 2021]. Disposal of the laundering activities down the drain is also responsible for effects on biological oxygen demand (BOD), and chemical oxygen demand (COD) [Gupta and Sekhri, 2021]. Because these surfactants are highly soluble in water, they remain resistant to wastewater treatment activities and thus get discharged into aquatic bodies and cause further negative impacts on the species in these habitats [Romero Vega and Gallo Stampino, 2025; Johnson et al., 2021].

With applications across cosmetics, food, detergents and pharmaceuticals, surfactants have now become one of the most highly used petrochemical based compounds in the daily lives [Romero Vega and Gallo Stampino, 2025; Bezerra et al., 2018; Rocha e Silva et al., 2018; Moldes et al., 2021]. Given their widespread use and the growing environmental and health concerns, innovation is now transitioning towards synthesizing sustainable alternatives made from plants, animals or microbes [Romero Vega and Gallo Stampino, 2025; Bezerra et al., 2018; Barbosa et al., 2022]. These alternatives are often addressed by several names including- natural surfactants, green surfactants, renewable surfactants, bio-based surfactants, or biosurfactants [Romero Vega and Gallo Stampino, 2025; Bezerra et al., 2018; Rocha e Silva et al., 2018; Alexandre et al., 2023].

Based on their origin, natural surfactants can be classified into two categories: 1. Natural surfactants- which are produced by plants 2. Biosurfactants- which are products obtained from the fermentation of oils, sugars, and alkanes with the help of microorganisms. [Rai et al., 2021; Holmberg, 2001; Wisetkomolmat, Suppakittpaisarn and Sommano, 2019]. The biosurfactants products are however rare, since their production costs are extremely high. Biosurfactants as compared to the chemically synthesized alternatives, are known for their persistence against changes to temperature, and pH. The biggest advantage of biosurfactants is their easily degradable nature as compared to the synthetic surfactants which are highly prone to causing numerous ecological problems. Biosurfactants are generally considered lesser harmful than the synthetic surfactants, often exhibiting lower toxicity, making them a promising choice for pharmaceutical applications [Roy, 2018; Chandran P. et al., 2010]. Examples include surfactin produced by B. subtilis [Roy, 2018; Cavalero and Cooper, 2003], rhamnolips produced by *P. aeruginosa* [Roy, 2018].

Based on their origin, biosurfactants can be further classified into first generation and second generation. The first generation biosurfactants are those which are sourced from either plant or animal-based origins. Their production includes chemical reactions of sugar esters, alkanolamines, saponins etc. On the other hand, second generation biosurfactants are the ones which are a result of some biological process such as bio-

http://doi.org/10.29369/ijrbat.2026.010.1.0004

catalysis or fermentation [Drakontis, Constantina Eleni and Amin, 2020; Farias CBB, Almeida FCG, Silva IA et al., 2021]. The examples of second generation biosurfactants include sophorolipids, rhamnolipids, glycolipids etc. [Romero Vega and Gallo Stampino, 2025].

Given their numerous benefits, recent years have seen growing attention towards plant based and naturally derived surfactants. The exploration, extraction, and isolation of natural surfactants from plants has thus been an area of active research [Rai et al., 2021; Moghimipour et al., 2020].

This article aims to discuss the recent studies on naturally derived surfactants and detergent formulations. It summarises the key natural sources investigated and wherever available, also the experimental approaches used to evaluate their activity. By presenting an overview of selected recent studies, this paper aims to highlight the demonstrated potential of natural materials for detergent and surfactant applications, along with the research gaps and limitations that need to be addressed for their wider adoption. Throughout this paper, the term "natural surfactant" has been used to represent all the natural and renewable source based surfactants.

3. RESULTS AND DISCUSSION:

The authors in their study *Rai et al.,2021* have highlighted the importance of plant-based surfactants given the rise in the demand of natural surfactants. They have discussed about 'Saponins' which are a class of metabolites that contain polar glycone moieties and non-polar aglycones structure moieties, making them both biodegradable and eco-friendly. The authors have presented a review of the surface-active properties of saponins by studying the various articles in literature that have discussed the surfactant properties of surfactants in comparison to synthetic surfactants. They mention that these plant-based metabolites have the potential to replace the commercial products due to their strong surface activities. The authors have also presented challenges associated to using natural materials in conventional synthetic products such as- extraction, processing, costs, and introduction of saponins as a low-cost alternative in the market [Rai et al., 2021].

In their article *Sülar et. al, 2024* have compared the activities of eco-friendly boron-based laundry detergent vs the standard commercial detergents. They studied the effects on three types of fabrics- cotton, polyester, and viscose through sequential washing cycles followed by comparative analyses and colour assessments. Their washing cycle tests showed that the boron-based detergent exhibited a diminishing colour strength especially in the polyester and cotton. The authors concluded that the boron containing detergent exhibited recurringly good stain removal capabilities especially on cotton fabrics. The eco-friendly boron-based detergent can show effective cleaning of the textiles, but the authors have stressed that they come with a drawback of colour fading on some fabrics as compared to the conventional commercial grade detergents. Their study highlights this important trade-off to be considered when researching about the potential of activities of green detergents [Sülar, 2024].

In another study P Sathya et al., 2017, to assess the cleaning and sanitization effects of natural plant- based materials- lime, aloevera, soapnut. The aim was to understand the cleaning activity by natural materials and their potential to replace harmful chemical-based products. This was done using different tests like solubility, pH, surface tension, and foaming tests. Their study and tests concluded that out of all the ingredients lime had the highest efficiency in cleaning and sanitization. They found that because the pH of lime was the lowest and its surface tension was the highest, that gives it giving it a powerful penetration power and wetting action for cleaning purposes [P Sathya et al., 2017].

http://doi.org/10.29369/ijrbat.2026.010.1.0004

In their study, Pravin Dhakite, B.W. Phate and B.B. Gogte, 2011, have studied the testing of their formulation of eco-friendly detergent powders and liquids. This was then further compared to the conventional detergent powder.

They focused on making them more environmentally friendly by minimizing the use of phosphate builders and by using alternatives like sorbitol. They were able to create formulations that showed matching levels of cleaning abilities with the commercial samples [Pravin Dhakite, B.W. Phate and B.B. Gogte, 2011].

In a recent article Romero Vega and Gallo Stampino, 2025, have presented an overview of various bio-based surfactants and biosurfactants. They have discussed how most of the bio-based surfactants are only produced on a lab-scale and their production for commercial scales is not yet standardized. Although rising acceptance and utilization of green chemistry principles is pushing the production of natural surfactants, there are still major challenges that need to be addressed. These include high cost of production, low productivity, production yield variability, high sensibility to environmental conditions, and lack of standardization [Romero Vega and Gallo Stampino, 2025].

The article by Deshmukh, Gogte and Yenkie, 2015, discusses sugar polymeric surfactants and their role as an eco-friendly detergent. The author has mentioned that sugar is largely available in the nature and that it is harmless to textiles and human skin and has better chances of degradability. However, they have highlighted that the production costs associated with their production can be higher as compared to synthetic ones, thus hampering their scalability. An important point mentioned is that sugar-based detergents produce lesser foam as compared to the conventional detergents. Sugar based polymeric surfactants thus poses various advantages and rising consumer awareness is certainly creating a demand for environmentally friendly products in the market. The author have pointed that application of green chemistry principles should be targeted to lower the commercial prices of the sugar based polymeric surfactants [Deshmukh, Gogte and Yenkie, 2015].

In the article by Waran et. al., the researchers noted that the presence of detergents in wastewater hampers the efficiency of treatment plants [Waran et al., 2025; Mousavi and Khodadoost, 2019] and hence, when considering plant based surfactants, it is also important to evaluate their toxicity and how effectively they can be neutralised during wastewater treatments [Waran et al., 2025]. With rising dependence on hardwater, dependency on detergents has also increased thus adding on to an increased risk of water pollution [Waran et al., 2025; Camerson, 2011]. For instance, linear alkyl benzene sulphonate (LAS) hinders the anaerobic digestion of waste water at half-maximal effective concentration (EC50) of 14 mg L^{-1} [Waran et al., 2025; Garcia et al., 2006]. Alkyl benzene sulphonate (ABS) and LAS remain detectable at 3.5 km and 0.6 km down the gradient respectively, underscoring that untreated laundry wastewater is capable of polluting groundwater [Waran et al., 2025; Thurman, Barber and LeBlanc, 1986]. In that context, the authors in their study compared the environmental impacts of the plant/natural based surfactants with the conventional laundry detergents. Their plant based surfactant cohort included soapnut from *Sapindus mukorossi (SMU)* and *Sapindus trifoliatus (STR)* and soap bark from *Quillaja Saponaria (QUI).* The activities were compared with pethroleum derived detergents-sodium lauryl sulphate (SLS) and LAS and commercial liquid (LQD) and powder detergents (DET). The toxicity tests revealed that soapnuts, SLS and LAS were more harmful to the Zebrafish *Danio rerio*. They pinpointed that soapnuts are suitable ingredients in detergents only if their toxicity is neutralised for instance by using

http://doi.org/10.29369/ijrbat.2026.010.1.0004

microbial consortia in the anaerobic treatment process [Camerson, 2011].

4. Conclusion:

The use of detergents and laundry products has grown exponentially with them becoming a common item in every household. The use of the synthetic petroleum based detergents causes serious implications to health, environment and sustainability. Natural and plant based surfactants and detergents can cater to these demands due to their numerous beneficial properties like- abundant and renewable origins, safety, eco-friendly and reduced toxicity. A global transition towards sustainable materials can be seen mainly due to- customer awareness, health prioritisation and the need to meet circular economy and environmental impacts goals. This has increased the interest in naturally derived and plant based surfactants mainly due to their excellent properties like- biologically safer, reduced environmental impact and less toxic. In India, the use of safe, sustainable and natural based detergents and surfactants are linked to the country's traditional cleaning practices.

Within the scientific community, there has been an increased search for more and more natural substrates as substitutes to the chemical ingredients in the surfactant and detergent products. However, plant/natural based surfactant technology still demands more systematic research and advances especially in the areas of- better separation techniques, increased testing to improve method standardisation and uniformity across product batches. These challenges have created several opportunities for research in this field. To improve their suitability to the commercial market, the production of natural surfactants and detergents needs to be shifted from the current laboratory scale to standardised large-scale industrial levels. Integration of principles of green and environmental chemistry with the current scientific and industrial research is being approached. More life cycle assessments studies of production and usage of natural surfactants should be conducted to analyse their environmental impacts. With the rising need for sustainable products and environmentally friendly practices and a depleting petroleum supply, it can be projected that in the coming years the natural surfactant market might overtake the synthetic surfactant market.

REFERENCES:

Imarcgroup.com. (2025). *Laundry Detergent Market India - Size, Share, Outlook, 2033*. [online] Available at: https://www.imarcgroup.com/india-laundry-detergent-market.

Vildan Sülar, Gülşah Ekin Kartal and Gözde Sezgin Şahin (2024). A comparative research on knitted fabrics washed with eco-friendly detergent for different washing cycles. *Coloration Technology*. doi:https://doi.org/10.1111/cote.12766.

Ali A, Hossain D and Shahid MA. Development of Eco-friendly Garments Washing for Localized Fading Effect on Garments: A Future Sustainable Process for Single Step Dyeing Fading Effect. (n.d.). Available at: https://austinpublishinggroup.com/textile-engineering/fulltext/arte-v3-id1022.pdf [Accessed 24 Feb. 2026].

Dave, N. and Joshi, T. (2017). A Concise Review on Surfactants and Its Significance. *International Journal of Applied Chemistry*, 13(3), pp.663–672. doi:https://doi.org/10.37622/ijac/13.3.2017.663-672.

Rosen, M.J. (1978) *Surfactants and interfacial phenomena*. 1st edn. New York: John Wiley & Sons.

Schott, H. (1985). Surfactant systems: Their chemistry, pharmacy and biology. *Journal of Pharmaceutical Sciences*, *74*(10), 1140–1141. https://doi.org/10.1002/jps.2600741040

Holmberg, K., Jönsson, B., Kronberg, B. and Lindman, B. (2002). Surfactants and

http://doi.org/10.29369/ijrbat.2026.010.1.0004

Polymers in Aqueous Solution. doi:https://doi.org/10.1002/0470856424.

Rai, S., Acharya-Siwakoti, E., Kafle, A., Devkota, H.P. and Bhattarai, A. (2021). Plant-Derived Saponins: A Review of Their Surfactant Properties and Applications. *Sci*, 3(4), p.44. doi:https://doi.org/10.3390/sci3040044.

García-Becerra, F.Y., Allen, D.G. and Acosta, E.J. (2010). Surfactants from Waste Biomass. pp.167–189. doi:https://doi.org/10.1002/9780470686607.ch9.

Sparg, S.G., Light, M.E. and van Staden, J. (2004). Biological activities and distribution of plant saponins. *Journal of Ethnopharmacology*, 94(2-3), pp.219–243. doi:https://doi.org/10.1016/j.jep.2004.05.016.

Vincken, J.-P., Heng, L., de Groot, A. and Gruppen, H. (2007). Saponins, classification and occurrence in the plant kingdom. *Phytochemistry*, [online] 68(3), pp.275–297. doi:https://doi.org/10.1016/j.phytochem.2006.10.008.

Gunjal, P. and Amin, V. (2025). A Comprehensive Literature Review On The Indian Soap Industry: Trends, Challenges, And Consumer Dynamics. [online] 13(7), pp.2320–2882. Available at: https://ijcrt.org/papers/IJCRT2507013.pdf.

Aruna Jyothi Kora (2024). Renewable, natural, traditional dish wash cleaning materials used in India: an overview. *Bulletin of the National Research Centre/Bulletin of the National Research Center*, 48(1). doi:https://doi.org/10.1186/s42269-024-01185-3.

Lawagon, C.P. and Amon, R.E.C. (2019). Magnetic rice husk ash 'cleanser' as efficient methylene blue adsorbent. *Environmental Engineering Research*, 25(5), pp.685–692. doi:https://doi.org/10.4491/eer.2019.287.

Yenugu KM (2014) Vintage ugadi vendi ginni (silver bowl). Antiques-Home museum, vol 2013

Srinivasan, P. (2019). *Make natural cleansers are easy to make, toxic-free and economical.* [online] The Hindu. Available at: https://www.thehindu.com/sci-tech/energy-and-environment/make-natural-cleansers-are-easy-to-make-toxic-free-and-economical/article27721105.ece [Accessed 24 Feb. 2026].

Kora, A.J. (2019). Leaves as dining plates, food wraps and food packing material: Importance of renewable resources in Indian culture. *Bulletin of the National Research Centre*, 43(1). doi:https://doi.org/10.1186/s42269-019-0231-6.

Kora, A. J., Rastogi, L., Kumar, S. J., & Jagatap, B. N. (2017). Physico-chemical and bacteriological screening of Hussain Sagar lake: An urban wetland. *Water Science*, *31*(1), 24–33. https://doi.org/10.1016/j.wsj.2017.03.003

Van Hoof, G., Fan, M. and Lievens, A. (2017). Use of product and ingredient tools to assess the environmental profile of automatic dishwashing detergents. *Journal of Cleaner Production*, 142, pp.3536–3543. doi:https://doi.org/10.1016/j.jclepro.2016.10.114.

Tusseau-Vuillemin, M.-H. (2001). Do Food Processing Industries Contribute to the Eutrophication of Aquatic Systems? *Ecotoxicology and Environmental Safety*, 50(2), pp.143–152. doi:https://doi.org/10.1006/eesa.2001.2083

Greenmoksha. (2015). *Green power!! Greener Alternatives for Laundry and Cleaning Products Especially for Eczema and Sensitive Skin - Greenmoksha.* [online] Available at: http://www.greenmoksha.com/green-power-greener-alternatives-for-laundry-and-cleaning-products/.

http://doi.org/10.29369/ijrbat.2026.010.1.0004

Le Guenic, S., Chaveriat, L., Lequart, V., Joly, N. and Martin, P. (2018). Renewable Surfactants for Biochemical Applications and Nanotechnology. *Journal of Surfactants and Detergents*, 22(1), pp.5–21. doi:https://doi.org/10.1002/jsde.12216.

Waran, A. and Chandran, P. (2021). Cradle to grave: The multifaceted soapnut-an update on the applications of Sapindus spp. *Sustainable Chemistry and Pharmacy*, 24, p.100557. doi:https://doi.org/10.1016/j.scp.2021.100557.

Wisetkomolmat, J., Inta, A., Krongchai, C., Kittiwachana, S., Jantanasakulwong, K., Rachtanapun, P. and Rose Sommano, S. (2021). Ethnochemometric of plants traditionally utilised as local detergents in the forest dependent culture. *Saudi Journal of Biological Sciences*, 28(5), pp.2858–2866. doi:https://doi.org/10.1016/j.sjbs.2021.02.018.

Romero Vega, G. and Gallo Stampino, P. (2025). Bio-Based Surfactants and Biosurfactants: An Overview and Main Characteristics. *Molecules*, [online] 30(4), p.863. doi:https://doi.org/10.3390/molecules30040863.

Agger, J. W., & Zeuner, B. (2022). Bio-based surfactants: Enzymatic functionalization and production from renewable resources. *Current Opinion in Biotechnology*, *78*, 102842. https://doi.org/10.1016/j.copbio.2022.102842

Gupta, N. and Sekhri, S. (2021). Impact of Laundry Detergents on Environment-A Review. [online] 21(4), pp.149–158.

Johnson, P., Trybala, A., Starov, V. and Pinfield, V.J. (2021). Effect of synthetic surfactants on the environment and the potential for substitution by biosurfactants. *Advances in Colloid and Interface Science*, 288, p.102340. doi:https://doi.org/10.1016/j.cis.2020.102340.

Bezerra, K.G.O., Rufino, R.D., Luna, J.M. and Sarubbo, L.A. (2018). Saponins and microbial biosurfactants: Potential raw materials for the formulation of cosmetics. *Biotechnology Progress*, 34(6), pp.1482–1493. doi:https://doi.org/10.1002/btpr.2682.

Rocha e Silva, N.M.P., Meira, H.M., Almeida, F.C.G., Soares da Silva, R. de C.F., Almeida, D.G., Luna, J.M., Rufino, R.D., Santos, V.A. and Sarubbo, L.A. (2018). Natural Surfactants and Their Applications for Heavy Oil Removal in Industry. *Separation & Purification Reviews*, 48(4), pp.267–281. doi:https://doi.org/10.1080/15422119.2018.1474477.

Moldes, A.B., Rodríguez-López, L., Rincón-Fontán, M., López-Prieto, A., Vecino, X. and Cruz, J.M. (2021). Synthetic and Bio-Derived Surfactants Versus Microbial Biosurfactants in the Cosmetic Industry: An Overview. *International Journal of Molecular Sciences*, 22(5), p.2371. doi:https://doi.org/10.3390/ijms22052371.

Barbosa, F., Ribeaux, D., Rocha, T., Costa, R., Guzmán, R., Marcelino, P., Lacerda, T. and da Silva, S. (2022). Biosurfactants: Sustainable and Versatile Molecules. *Journal of the Brazilian Chemical Society*.

Alexandre, Attilio Converti, Rita and Leonie Asfora Sarubbo (2023). Biosurfactants as Multifunctional Remediation Agents of Environmental Pollutants Generated by the Petroleum Industry. 16(3), pp.1209–1209. doi:https://doi.org/10.3390/en16031209.

Holmberg, K. (2001). Natural surfactants. *Current Opinion in Colloid & Interface Science*, [online] 6(2), pp.148–159. doi:https://doi.org/10.1016/S1359-0294(01)00074-7.

Wisetkomolmat, J., Suppakittpaisarn, P. and Sommano, S.R. (2019). Detergent Plants of

http://doi.org/10.29369/ijrbat.2026.010.1.0004

Northern Thailand: Potential Sources of Natural Saponins. *Resources*, [online] 8(1), p.10.

Roy, A. (2018). A Review on the Biosurfactants: Properties, Types and its Applications. *Journal of Fundamentals of Renewable Energy and Applications*, 08(01). doi:https://doi.org/10.4172/2090-4541.1000248.

Preethy Chandran et. al. / International Journal of Engineering Science and Technology Vol. 2(12), 2010, 6942-6953

Cavalero, D.A. and Cooper, D.G. (2003). The effect of medium composition on the structure and physical state of sophorolipids produced by Candida bombicola ATCC 22214. *Journal of Biotechnology*, 103(1), pp.31–41.

Drakontis, Constantina Eleni and Amin, S. (2020). Biosurfactants: Formulations, properties, and applications. *Current opinion in colloid & interface science*, [online] 48, pp.77–90. Available at: https://agris.fao.org/search/en/providers/122535/records/65df22314c5aef494fe02e8a [Accessed 24 Feb. 2026].

Farias CBB, Almeida FCG, Silva IA, et al. Production of green surfactants: Market prospects. Electron J Biotechnol 2021;51.

Moghimipour, E., Jasemnezhad, M., Mohammad Soleymani, S. and Salimi, A. (2020). Preparation and evaluation of a free surfactant herbal shampoo with Acanthophyllum Squarrosum Saponins. *Journal of Cosmetic Dermatology*, 20(1), pp.181–187.

P Sathya, AS Lejaniya, Sharon, Ajith, CT Sathian, K Radha and R Geetha (2017). Cleaning and sanitization efficiency of some cleansing agents of natural origin. *The Pharma Innovation Journal*, [online] 6(12), pp.105–107.

Pravin Dhakite, B.W. Phate and B.B. Gogte (2011). TESTING OF ECOFRIENDLY DETERGENT POWDER AND LIQUID DETERGENT. [online] 1(3)(20111), pp.432–436.

Deshmukh, A., Gogte, B. and Yenkie, M. (2015). Liquid Laundry Detergents Based on Novel Polymeric Surfactants. *International Research Journal of Pure and Applied Chemistry*, 5(1), pp.91–98. doi:https://doi.org/10.9734/irjpac/2015/12459.

Waran, A., Reghunandan Pillai, S., Kulkarni, S. and Chandran, P. (2025). Comparing the environmental impacts and toxicity of laundry detergents with soapnuts and other tree-based natural surfactants. *The holistic approach to environment*, 15(4), pp.137–149. doi:https://doi.org/10.33765/thate.15.4.1.

Mousavi, S.A. and Khodadoost, F. (2019). Effects of detergents on natural ecosystems and wastewater treatment processes: a review. *Environmental Science and Pollution Research*, [online] 26(26), pp.26439–26448. doi:https://doi.org/10.1007/s11356-019-05802-x.

Camerson, B. (2011). Detergent Considerations for Consumers: Laundering in Hard Water—How Much Extra Detergent Is Required? *Journal of extension*, 49(4). doi:https://doi.org/10.34068/joe.49.04.21.

Garcia, M.T., Campos, E., Sánchez-Leal, J. and Ribosa, I. (2006). Effect of linear alkylbenzene sulphonates (LAS) on the anaerobic digestion of sewage sludge. *Water Research*, 40(15), pp.2958–2964. doi:https://doi.org/10.1016/j.watres.2006.05.033.

Thurman, E.M., Barber, L.B. and LeBlanc, D. (1986). Movement and fate of detergents in groundwater: a field study. *Journal of Contaminant Hydrology*, 1(1-2), pp.143–161. doi:https://doi.org/10.1016/0169-7722(86)90013-6.

http://doi.org/10.29369/ijrbat.2026.010.1.0004