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Traditional Building Knowledge in Indian Lime and Earthen Plasters

Conocimiento tradicional sobre revestimientos de tierra y cal en la India

Conhecimentos tradicionais de construção nos rebocos de cal e terra da Índia

Keywords | Palabras clave | Palavras chave

Indigenous knowledge, Inventory, Natural plasters, Stabilizers, Low-carbon

Conocimiento autóctono, Inventario, Revocos naturales, Estabilizadores, Baja en carbono

Conhecimentos indígenas, Inventário, Rebocos naturais, Estabilizadores, Baixa emissão de carbono

Abstract | Resumen | Resumo

India's traditional building systems and knowledge involving natural materials provide fine examples of low-carbon, place-adaptive architectural solutions as well as embodying simplicity and holistic sustainability. They utilize locally available materials prepared and applied so as to build structures and dwellings that are resilient to climate conditions and able to provide comfort and livability. Culturally, this knowledge is transferred orally from generation to generation and continuously recreated. Unfortunately these knowledge systems and practices have become endangered owing to a rupture in their continuity for reasons such as a preference for and incentivization of easier conventional solutions like cement and steel. With a focus on natural plasters used traditionally, this paper highlights some of these diverse plasters along with their natural additives.

Los sistemas de construcción tradicionales de la India y el conocimiento de los materiales naturales proporcionan buenos ejemplos de soluciones arquitectónicas bajas en emisiones de carbono y adaptadas al lugar, además de encarnar la simplicidad y una sostenibilidad holística. Estos sistemas utilizan materiales disponibles localmente, preparados y aplicados para construir estructuras y viviendas que resistan las condiciones climáticas y sean capaces de proporcionar comodidad y habitabilidad. Como cultura, este conocimiento se ha transmitido oralmente de generación en generación y se recrea de forma ininterrumpida. Por desgracia, estos sistemas y prácticas de conocimiento se han visto amenazados debido a una ruptura en su continuidad, entre otras razones, por la preferencia y el incentivo de soluciones convencionales más sencillas como el cemento y el acero. Este artículo, que trata de los revocos naturales utilizados tradicionalmente, profundiza en algunos de ellos y sus aditivos naturales.

Os sistemas de construção tradicionais da Índia e o conhecimento dos materiais naturais constituem bons exemplos de soluções arquitetónicas com baixa emissão de carbono e adaptadas ao local, além de incorporarem a simplicidade e a sustentabilidade holística. Utilizam materiais disponíveis localmente, preparados e aplicados de modo a construir estruturas e habitações resistentes às condições climáticas e capazes de proporcionar conforto e habitabilidade. Culturalmente, este conhecimento é transmitido oralmente de geração em geração e continuamente recriado. Infelizmente, estes sistemas de conhecimento e práticas são ameaçados por uma ruptura na sua continuidade, por razões como a preferência e o incentivo a soluções convencionais mais fáceis, como o cimento e o aço. Com um enfoque nos rebocos naturais utilizados tradicionalmente, este artigo destaca alguns destes diversos rebocos juntamente com os seus aditivos naturais.

Introduction

<u>Traditional Knowledge Systems in Indian Architecture and Construction</u>

India is home to some of the most ancient settlements and civilizations, with practices in construction and architecture tried and tested over centuries. This wealth of traditional knowledge appears in mud and lime structures varying across different landscapes and periods, from palaces and forts to humble dwellings, that show a deep understanding of natural materials and their properties passed down through generations of builders, craftspeople, and artisans.

An example of this is the vernacular *havelis* of Gondia, Maharashtra: mansions of mud built up to three stories, designed to respond to the climatic and social needs of their time. Their thick mud walls reduce heat gain and the rooms around the main chamber act as airways that cool the building, along with courtyards and verandahs offering seasonal heating and cooling solutions (Archinomy n.d.).

Among traditional earthen structures, small dwellings may seem insignificant compared to palaces and mansions. Yet they are important to understanding traditional architecture and its knowledge systems. India has many such structures, sparsely in urban areas and in dense clusters in its rural fabric. An example of the latter is the cluster of mud houses in the village of Meenakshipuram in Madurai, Tamil Nadu, with earthen walls built with cow dung and chopped straw. These clusters were analyzed for thermal performance and were shown to have notable temperature variations between their exterior and interior (Madhumathi et al. 2015:5).

The knowledge transfer involved in keeping these traditional practices alive has occurred orally, in a cycle of continuous recreation and usage. Unfortunately this knowledge is now endangered due to a disruption of the cycle for reasons such as lifestyle and occupational changes, urbanization, etc.

<u>Construction in India Today</u>

In an era of rapid development, the construction industry is a driving force of Indian modernization and globalization. With ever-rising demand for infrastructure, the industry is surging, with 10% annual growth in recent years (Sivagnana 2008). This boom has led to an influx of new materials and technologies that are put into use almost immediately, without sufficient research or understanding as to place adaptability, climate, embodied energy, industrial processing, or potential health hazards. Quick and easy housing solutions with cement and steel are being pushed and incentivized as “modern” materials, representative of a “developed” nation. This has led to the demolition of traditional dwellings without regard to their condition, longevity, or potential for sustainable reuse, as traditional technologies and building sciences using natural materials disappear.

At a time of multiple interrelated challenges such as climate change, housing shortage, loss and damage of culture and tradition, and community resilience, the study of traditional knowledge can provide solutions. Current trends point to an urgent need to take stock and to look into low-carbon alternatives that respond to local contexts and provide holistic answers.

Traditional Knowledge and its Role in Climate Mitigation

In the report *Realizing the Future We Want*, the UN System Task Team on the Post-2015 Development Agenda states that it is essential to explore the linkages between sustainable development and indigenous knowledge (UNESCO 2011). The traditional building knowledge of India has immense potential in this respect, with nearly all of its practices using natural, low-carbon, place-adaptive materials and techniques that are examples of sustainability and climate resilience. Knowledge loss has already led to the decline of several of these practices. It is therefore important to recognize indigenous peoples and their knowledge and the potential this has in climate action, sustainable development, and maintenance of biodiversity

Without pre-emptive measures, artisan communities and their knowledge systems will struggle to survive. Inventorying their traditions may be essential to safeguarding building knowledge for both individual and collective purposes. This knowledge can be adapted and used in sustainable, place-adaptive new building as well as in appropriate restoration and reuse of built heritage. Accordingly our paper documents traditional techniques using natural materials, with particular focus on plasters. Such inventories should be made generally accessible so as to encourage creativity and self-respect in the communities from which these intangible cultural heritage practices originate.

Methodology

We survey some traditional Indian construction practices including case studies and examples from our projects as well as literature and field studies.

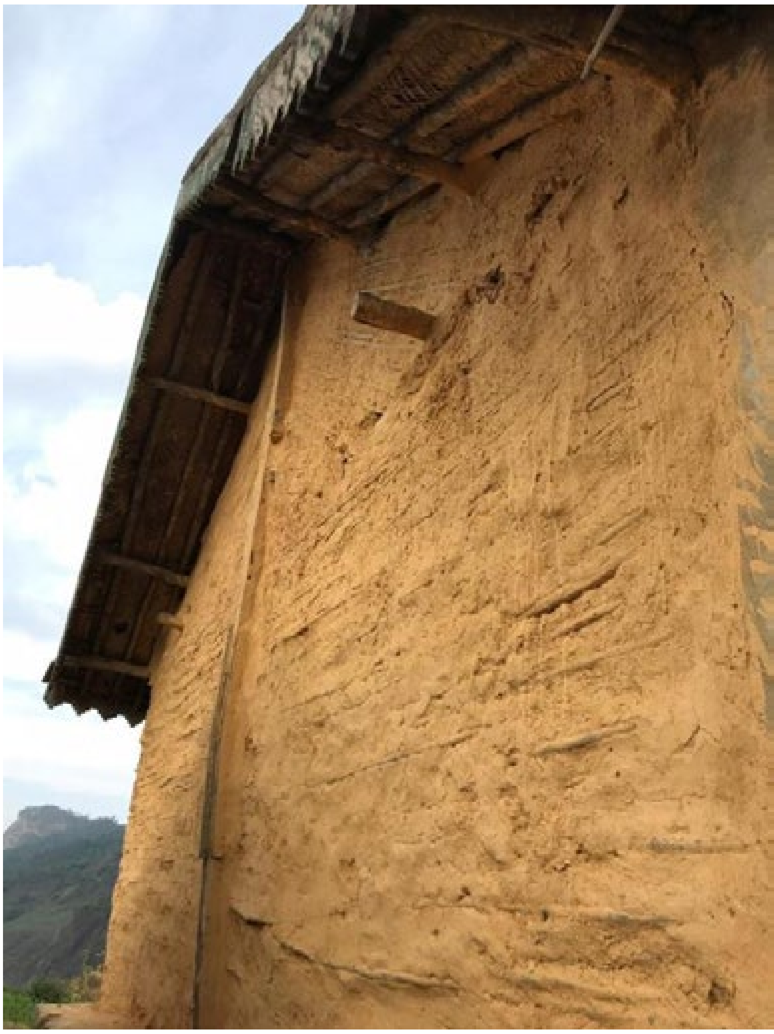
Our field studies take a triple approach of investigating living heritage, built heritage, and oral history, focusing on natural and traditional plastering techniques. Primary data were collected and assessed through interviews with artisans and other practitioners. This systematic documentation covers the various natural materials and their sourcing along with the properties they impart and their methods of preparation.

Natural Plasters in India

Earth and lime are two of the main materials in natural construction, with lime being the primary ingredient of mortar for stone or brick masonry. To protect this against harsh climatic conditions, a final layer of plaster is required. Protective natural plasters and also decorative ones were used on both the exteriors and interiors of temples, palaces, and even humble dwellings for centuries before the advent of today's conventional synthetic alternatives (Fig. 1).

Analytical investigation of the second-century rock-cut cave shrines of Karla in western India has revealed earthen plasters with antifungal, antibacterial, and insect-repellent properties derived from *Careya arborea* wild guava stem fibers used as a plaster additive. Further studies have shown the use of natural additives such as rice husk, milk fat, and vegetable oil to impart a variety of properties enhancing the performance of these renders (Dighe et al. 2019).

Figure 1: Traditional wattle and daub dwelling with earthen plaster (Kookal, Tamil Nadu, India, 2019)



Ancient Sanskrit treatises such as the fifth-century *Vishnudharmottara Purana* and the sixteenth-century *Silpa Ratna* record details of such plasters and mortars as well as the ingredients used, in detailed specifications (Bais 2015). A manuscript found in Padbhanabhapuram Palace in Kanyakumari details one lime plaster containing a combination of fifteen herbs (Thirumalini et al. 2011). Much knowledge of traditional Indian building practices and materials is transmitted not only orally but also by such written means as stone scriptures, copper plates, palm leaves, parchments, and paper. The hurdle here is one of accessibility to these writings and the knowledge they contain, as many are written in ancient and local scripts that are no longer understood unless translated and made available by scholars. Such documents are also often subject to restricted access.

In order to preserve and revive this knowledge of plastering, therefore, methodical documentation that can be made accessible to researchers, architects, builders, and society at large will be a valuable tool for both research and practice.

Plasters and Additives Studied

The Indian subcontinent is vast and diverse in its climate and topography. Variations at macro and micro level have led to settlements and communities developing unique, divergent responses to their specific contexts. Manifested in knowledge and tradition and deriving from the resources available and each region's cultural character, these responses have been tried and tested over centuries. Understanding this inherent diversity entails documenting a wealth of knowledge. With this in mind, we begin with a primary set of five Indian regions:

1) North: Cold and dry climate with mountain topography

2) West: Hot and dry climate with desert topography

3) East: Humid subtropical climate with riverine topography

4) Central: Subtropical climate with plateau topography

5) South: Tropical monsoon climate with coastal topography (Fig. 2)

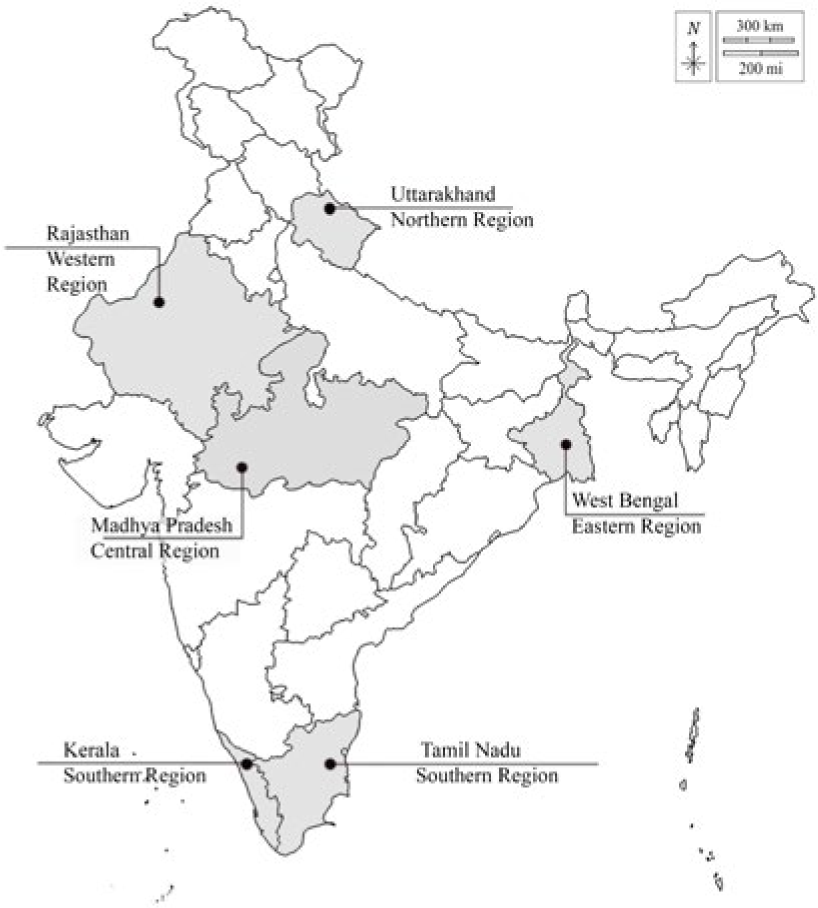


Figure 2: Map of India with the five regions and selected states for our study of traditional plastering techniques (Bangalore, India, 2024)

Given the plethora of techniques and materials present in each of these regions, our scope is limited to states in the West (Rajasthan) and South (Kerala and Tamil Nadu). The techniques selected are shown to be used over a range of construction types and scales. From the humble earthen dwellings of villages in Kerala to the lavish *araish* plaster palaces of Rajasthan, these methods reflect the craftsmanship of artisans and architectural realizations at every level of society and culture, and for all uses.

4.1. Rajasthani Lime Plasters – *Thappi* and *Araish*

The thappi and araish techniques are indigenous to the Rajasthani community of lime extractors, particularly from the city of Sardarshahar, known for its haveli mansions and their fine frescoes. The knowledge, practices, and even the tools used in this age-old method of working with lime have been passed down from generation to generation.

Thappi

Traditionally used as a base layer (*kada*), *thappi* is made from a mixture consisting mainly of slaked lime and *surkhi*, a substitute for pozzolana obtained by crushing fired clay bricks. The name *thappi* derives from the wooden tool used to beat the plaster once it has been applied so that its ingredients merge homogeneously (Fig. 3).

This also helps the lime to set, improves its adhesion to the substrate, repairs cracks that form as the lime dries, and increases the surface area, allowing uniform entrainment, carbonation, and drying. The pozzolanic reaction between the lime and the *surkhi* makes this plaster impermeable to water. Hence it is used increasingly in rainy areas, especially on flat stone-slab roofs, as it prevents leaks as well as acting as a thermal barrier (Fig. 4).

Figure 3: *Thappi* plastering with the eponymous wooden tool (Bagalur, India, 2023)

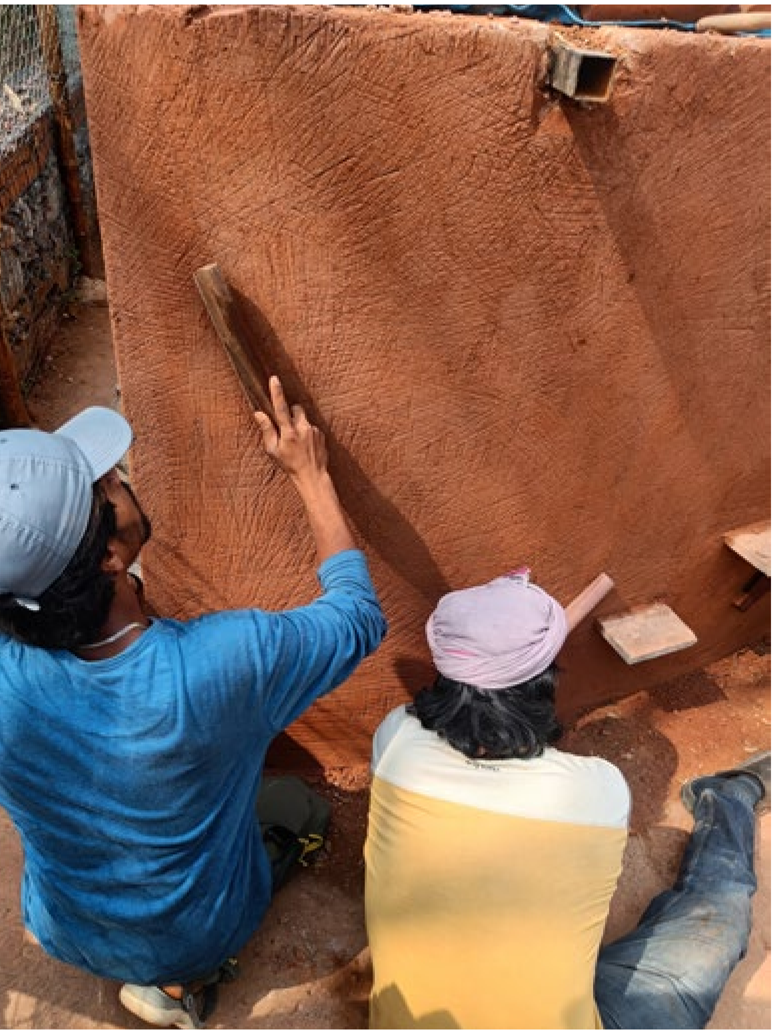


Figure 4: *Thappi* plastering on a brick and lime mortar water tank (Bagalur, India, 2023)

Ingredients and Preparation:

- *Thappi* consists first of a dry mix of two parts of *surkhi* and a half part of sand, to which one part of slaked lime is added to prepare a wet mix (Fig. 5).

- Water is added as required to make a paste. This mixture is traditionally stored in earthen pots in dark rooms or other shady places allowing the lime's hydration to be maintained for one to two days (maximum of three) before use.

- The primary natural additives used in the preparation of *thappi* are fermented water of jaggery (*gud*) (one kilo in five liters of water), and fenugreek seeds (*methi*) (one kilo in ten liters of water) (Fig. 6). Gall nuts (*kaddukai*) can also be used instead of fenugreek (Fig. 7).

- The saccharine acid in jaggery is known to improve lime's waterproofing characteristics (Dharampal 1973). Other unrefined sugar substitutes are used in other parts of India.

- The jaggery water is added directly to the prepared mix before use and can also be added to the lime during slaking (Bais 2015).

- The addition of fenugreek water is known to improve the plaster's workability and adhesion. The solution is prepared by grinding the seeds and soaking the resultant powder overnight. This is then mashed and sieved to remove particles. The water is added to the plaster before application.

- Once the plaster has been well mixed with the additives, it is "thrown" onto the wall with a trowel. This ensures that there are no air pockets between the surface and the plaster.

- The plaster is smoothed as it begins to dry and beaten using the wooden tool also called *thappi* (Fig. 8).

<u>*Araish*</u>

The word *araish* translates as "mirror". This lime plaster gives a shiny, smooth, and watertight finish over *thappi* or any other plaster substrate (*kada*). This exquisite coating is commonly seen on the walls of Rajasthani palaces (Figs. 9 and 10).

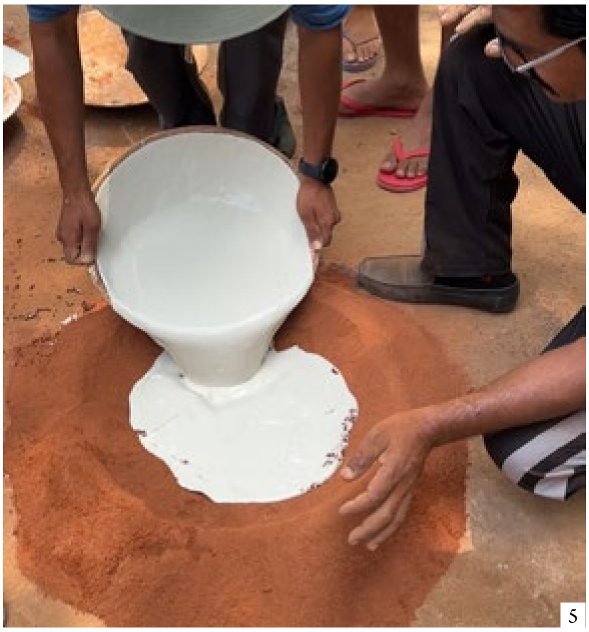

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Figure 5: Preparation of *thappi* plaster: addition of slaked lime (Bagalur, India, 2023)

Figure 6: Fenugreek seeds (Shailesh Humbad)

Figure 7: Addition of jaggery and fenugreek water (Bagalur, India, 2023)

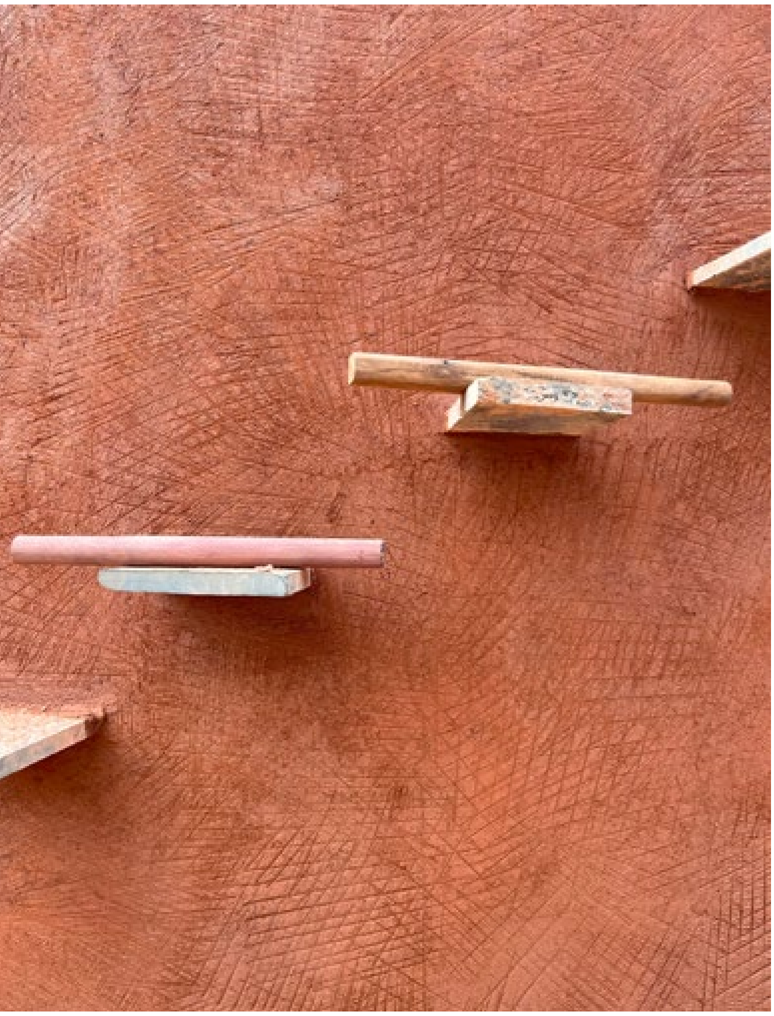


Figure 8: *Thappi* texture (Bagalur, India, 2023)

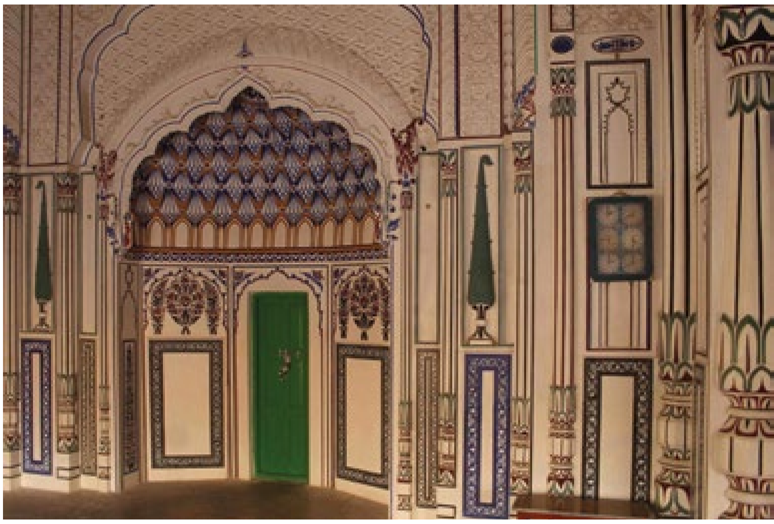


Figure 9: *Araish* plaster in Juma Masjid, Tonk (Thannal Natural Homes, Rajasthan, India, 2018)

Figure 10: *Araish* tile and balls (Bagalur, India, 2023)

Ingredients and Preparation:

- The preparation of quicklime for *araish* is very special. Traditionally it is slaked for over two years in a controlled environment and sieved through a muslin cloth. Any undesired minerals are removed with the addition of curds or yogurt (Bais 2015).

- The mix for *araish* is obtained by blending one part of slaked lime with one part of marble dust.

- Lime slurry is added to this dry mix, up to the desired consistency.

- The mix of lime and marble dust is further ground by hand in a traditional stone grinder for over an hour, until smooth (Fig. 11).

- Great care is taken to ensure that the lime remains free of dust and other impurities. The mix is then left for a day to settle in a cool and shady place before use.

- The plaster is applied with special tools, handcrafted and handed down through generations of artisans (Figs. 12 to 15). Small trowels with crafted handles are used to apply it to the surface and it is smoothed using wooden tools.

- The shiny, mirror-like finish is achieved by burnishing the surface as it starts to dry with a pebble or any smooth semi-precious stone (Fig. 16).

- Once the finish is nearly smooth, ground *singharaj* stone is dusted over it for further shine and polish.

Figure 11: Grinding of lime paste for *araish* plaster using stone tools (Bagalur, India, 2023)

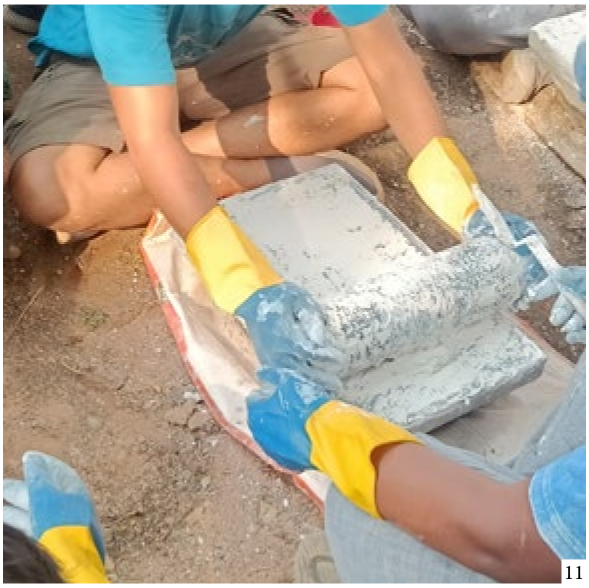
Figure 12: Set of ancestral handcrafted tools used in Rajasthani lime plastering (Bagalur, India, 2023)

Figure 13: Application of *araish* with a wooden tool (Bagalur, India, 2023)

Figure 14: *Araish* plastering with a small trowel (Bagalur, India, 2023)

Figure 15: Smoothing of *araish* plaster with a small trowel (Bagalur, India, 2023)

Figure 16: Burnishing of *araish* with a pebble (Bagalur, India 2023)



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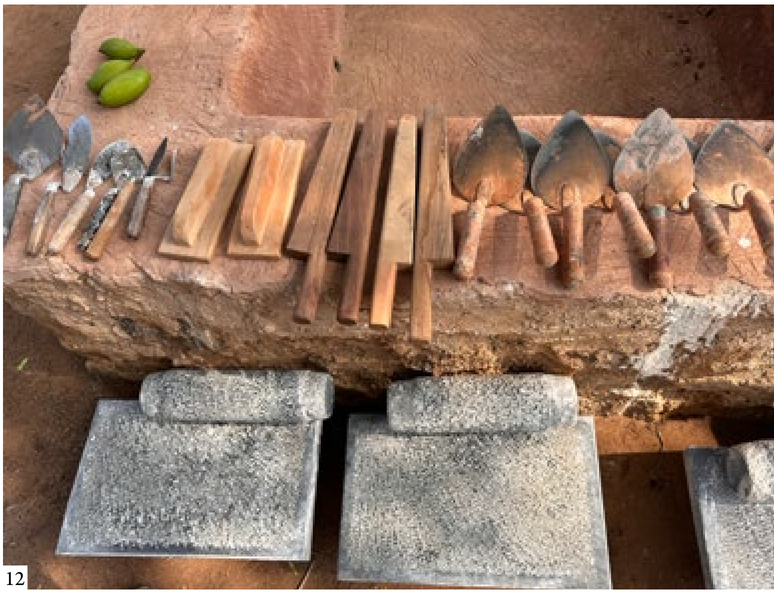

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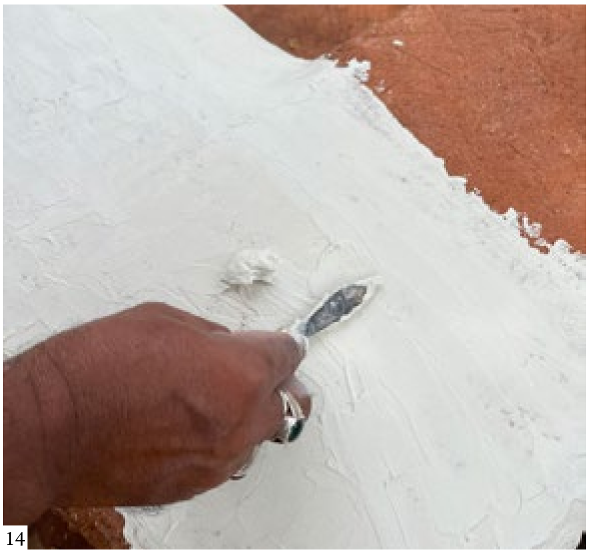

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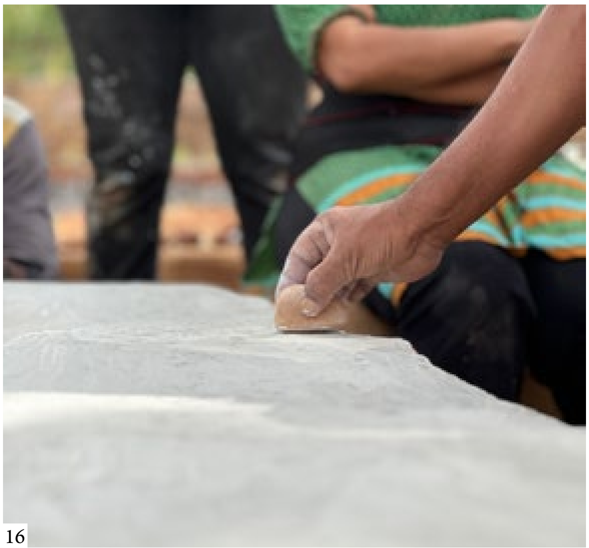

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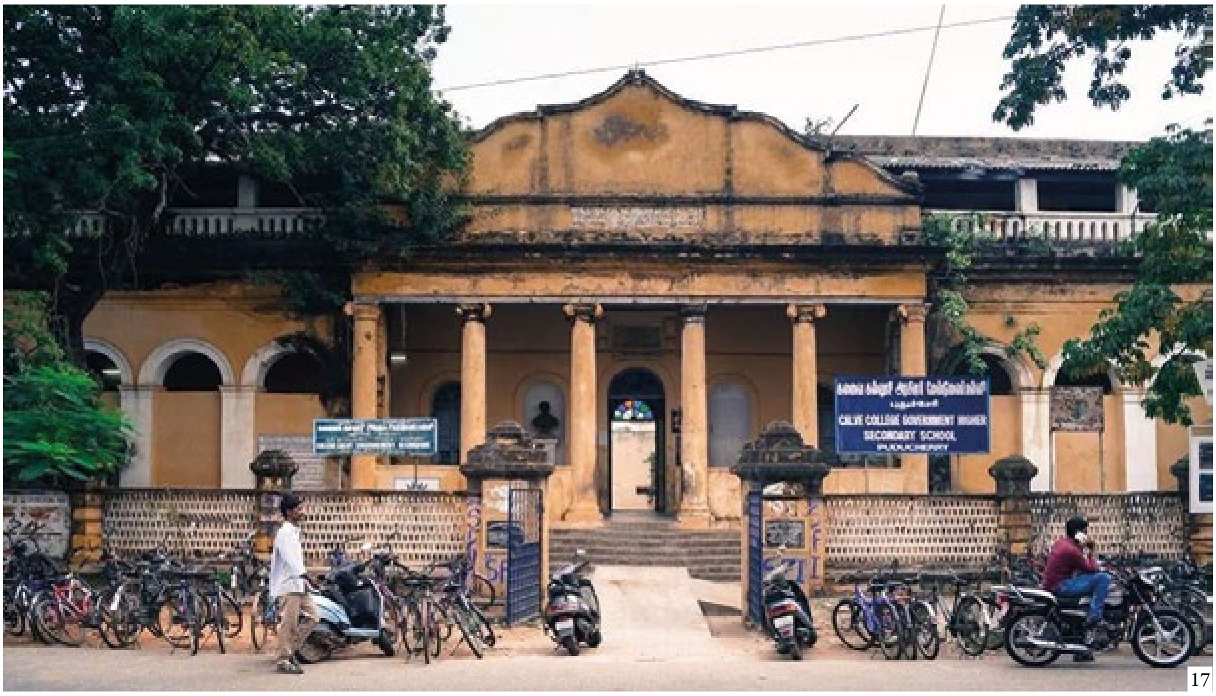
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4.2. Rock Lime Plaster from Pondicherry, Tamil Nadu

The preparation of rock lime by this technique is common to Pondicherry and parts of Tamil Nadu with rich limestone deposits such as Salem, Tiruchirappalli, Ariyalur, Madurai, etc. (Tripathy et al. 2023) (Fig. 17).

Ingredients and Preparation:

- The lime is prepared by sprinkling water over the rocks until it disintegrates into powder.
- The powdered lime is then strained through a 2 mm sieve and the bigger particles are further broken down or else left for use in brick mortar.
- One part of this fine powder is mixed with three parts of sand and the mixture is left to ferment in a tank for 15 days under a 3-inch-thick layer of water to prevent setting (Figs. 18 to 20).
- The organic additives used in the preparation of this mortar include fermented water of *kaddukai* (*Terminalia chebula*) seeds and jaggery (Fig. 21). This is prepared by cracking two kilos of *kaddukai* seeds (Fig. 22), which are then tied in a muslin cloth to prevent any flakes from contaminating the mix and soaked in 50 liters of water with two kilos of jaggery for one week before use. *Kaddukai* is widely cultivated in the state of Tamil Nadu and its use with jaggery facilitates early carbonization, enhancing the lime's bond and strength.
- The solution is added to the lime plaster mix just before application.


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Figure 17: Calve College in Pondicherry, a heritage building finished with lime plaster (vascco.in)

Figure 18: Application of rock lime plaster (Jayapura, India, 2023)

Figure 19: Rock lime plaster once applied (Jayapura, India, 2023)

Figure 20: Two types of rock lime plaster mix (Jayapura, India, 2023)

Figure 21: *Gud* or jaggery: sugarcane-derived crystallized cubes or blocks of raw sugar (Giridhar Appaji Nag Y - Flickr)

Figure 22: Cracking of *kaddukai* seeds (Bagalur, India, 2022)

4.3. *Madras Chunam* from Chennai, Tamil Nadu

Madras chunam ("chunam" being a transliteration of *cuṇṇāmpu*, meaning "lime" in Tamil) refers to a particular type of lime plaster commonly used in Chennai (Madras). It was studied by British officials in the colonial period and noted for its unique use of organic ingredients. An early record of the technique appears in *A Practical and Scientific Treatise on Calcareous Mortars and Cements, Artificial and Natural* by Louis-Joseph Vicat (1837). It is also documented by Dharampal in his volume *Indian Science and Technology in the Eighteenth Century* (Dharampal 1973).

Ingredients and Preparation:

- This plaster is made with shell lime calcined with charcoal, with one part mixed with one and a half parts of river sand. In this base mixture the additives and their proportions vary according to the number of coats and the plaster's uses.
- For the second coat, a mix of three parts of lime to one part of sand is prepared and applied over the first coat once dry.
- In the third coat, a mix of four parts of lime and one part of sand is prepared and ground to a fine paste. To this are added egg whites (12), curds (1.5 parts), and ghee butter (Shua 2023) for every 600 grams of plaster mix. The addition of egg white and curd gives a glossy finish and makes the plaster waterproof, and the casein in the curds acts as a binder and prevents dustiness.

4.4. *Vellai Poochchu*, Chettinad Plaster from Tamil Nadu

This form of lime plastering is a traditional technique originating from Chettinad in Tamil Nadu and can be widely seen in many of the mansions built in the 1700s by the Nattukottai Chettiar community (Fig. 23). It is known for its smooth glossy finish similar to that of *araish*. The technique involves applying six thin layers of plaster, with proportions and additives varying each time, and a final coat with the addition of egg white (Radhakrishnan 2014).

Ingredients and Preparation:

- The base coat of Chettinad lime plaster is a mix of one part of shell lime to three parts of coarse river sand, as an intermediate coating to bind the wall substrate to subsequent coats.
- This mixture must be left to soften for seven days.
- It is then beaten with a wooden pole until it becomes sticky. Additives such as fermented water of *kaddukai* and jaggery may now be blended in.

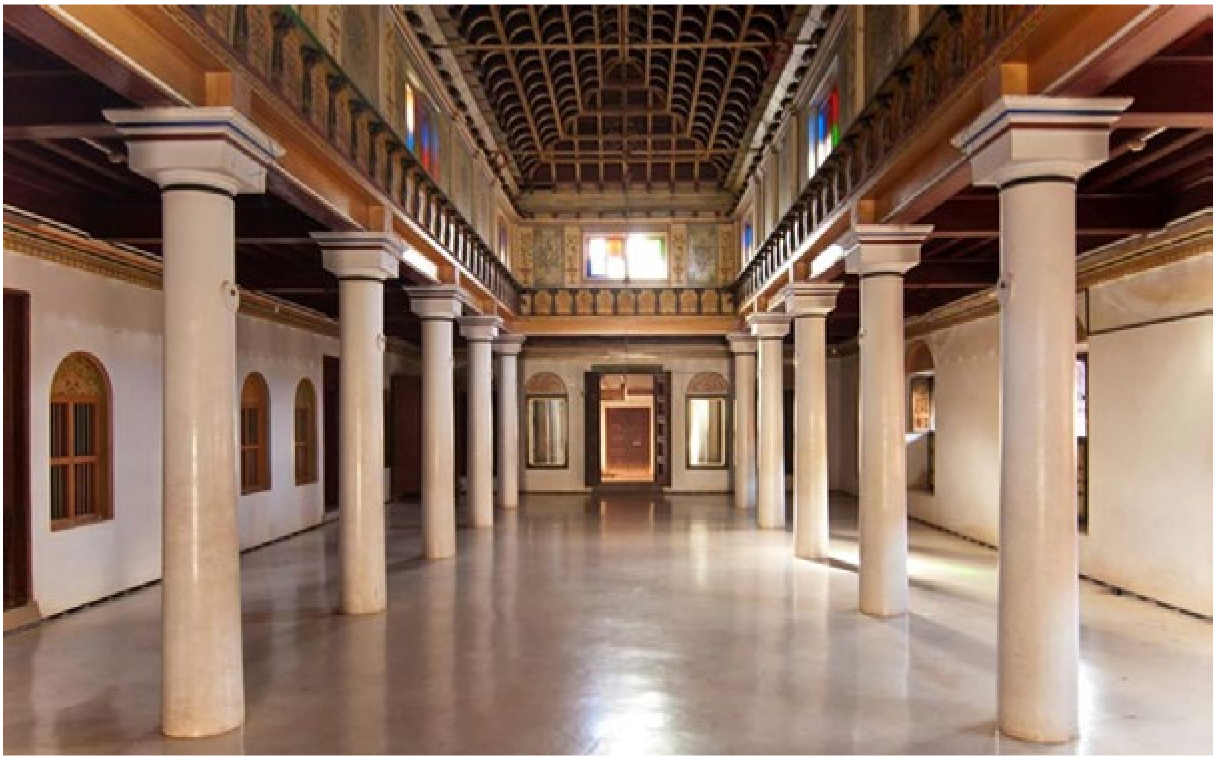
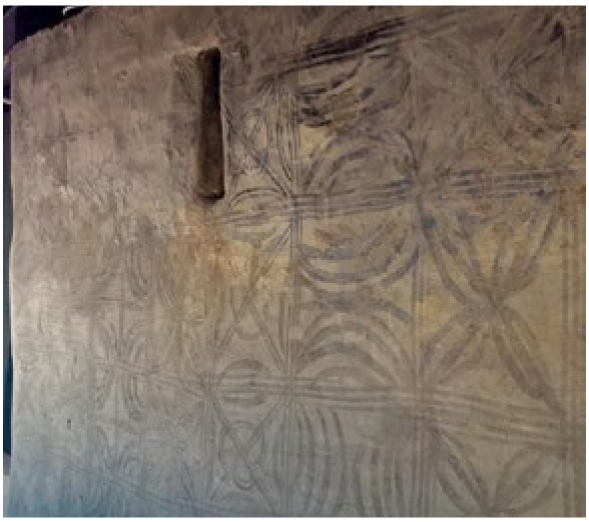


Figure 23: Chettinad mansion with Chettinad plaster on walls and floors (M.rm.rm foundation, Visalakhai Ramaswamy, 30 Stades)

- The subsequent layers, from the second to the fifth, are a mix of slaked lime and white stone powder (*kalmavu*). The particles in these layers are finer and the mix is left to soften for two days before being beaten and applied.

- The sixth and final coat also includes egg white. This is lightly whisked to achieve a foamy texture and then added to the plaster mixture. The egg white lightens the mix, making it soft and reducing shrinkage and cracking. Milk whey can be added as a substitute, along with pigments. In some cases the use of tallow (*vajjram*) has been noted (Tripathi 2023).



4.5. Earthen Plaster from Wayanad, Kerala

The earthen dwellings of the Wayanad region are built mainly of wattle and daub (*alagu*) in the Thirunelly district. Houses of adobe blocks (*mannu katta*) are found near Manathavadi, such as at Koyileri (Fig. 24) and Kudiyoor near Thirunelly. These are plastered with mud in the final layers using natural additives from local woodland. The bark and leaves of the *ooravu* or *kulamavu* tree (*Persea macrantha*) are used to improve and strengthen the plaster mix.

Ingredients and Preparation:

- The adobe walls are first coated with a mix of soil and rice husk; the water used to prepare this mix is replaced with a sticky solution prepared with *ooravu* bark.

- This involves cutting the bark and placing it in a tub of water, which after a day or two turns sticky.

- This solution is mixed into the soil until a pasty consistency is achieved.

- The rice husk, locally called *ummi*, is then added and mixed with the wet soil mixture and left to ferment for a day or two. This layer can be repeated if necessary to achieve an even finish.

Figure 24: Earthen dwelling with mud plaster (Wayanad, India, 2018)

- For the final layer, ash from burnt rice husk is blended with the *ooravu* solution. This layer is applied using a muslin cloth, with simple decorative patterns being drawn with the fingers.

4.6. Final Coatings

Depending on each region and its resources, natural earth and lime plasters are often given a final coat of wax or other oily substance. This coating acts as a sealant, adding sheen and preventing dustiness. In some cases it may also serve as a water repellent.

Avanakka, Castor Tree (*Ricnius communus*)

The leaves of *Avanakka Maram*, also known as castor tree (Fig. 25), are moistened and then rubbed over plaster to give a protective coating, and can also be a substitute for carnauba wax. Carnauba wax has been known to be used as a wax coating for mud floors (Milesi 2012).

Koovalam Kaya, Indian Bael (*Aegle marmelos*)

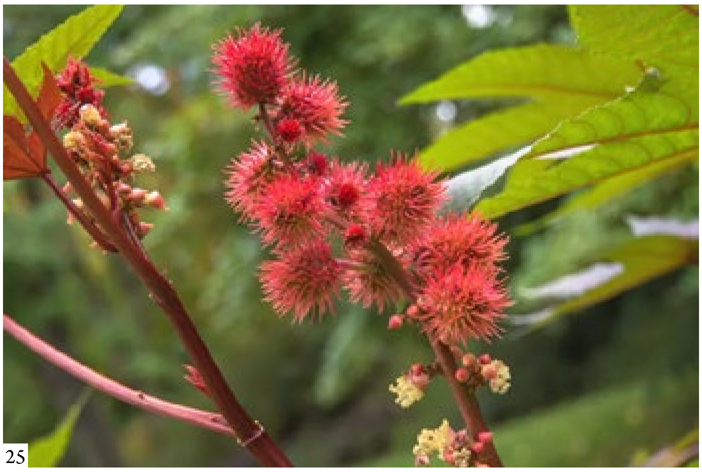
Indian bael fruit produces an extremely sticky gum which is used as a coating on mud plasters and is said to increase water resistance (Fig. 26). In Maharashtra it has been used in combination with jaggery, heated with water until the mix thickens, and coated over mud plaster to make it more resistant and weatherproof.

Veppu Pasha, Neem Tree (*Azadirach ta indica*)

Veppu Maram is commonly known as the neem tree, and *Veppu pasha* is its gum. The glue in its bark and the gum in its leaves are used in mural painting to bind pigments so that they adhere to the substrate (Fig. 27). Neem gum can be used interchangeably with gum arabic. It has been known to be used on lime plasters and as a final coat on mud plasters to prevent dustiness.

Vajra Pasha

Vajra pasha is a wax used formerly to seal letters or envelopes. When melted, it turns into a colorless sealant. In traditional limewashes, it has been used to give a final coat to prevent dustiness. In Ayurveda it is used as a coating for pills so that they retain their shape. Jute gunny bags are also dipped into this wax to enhance durability.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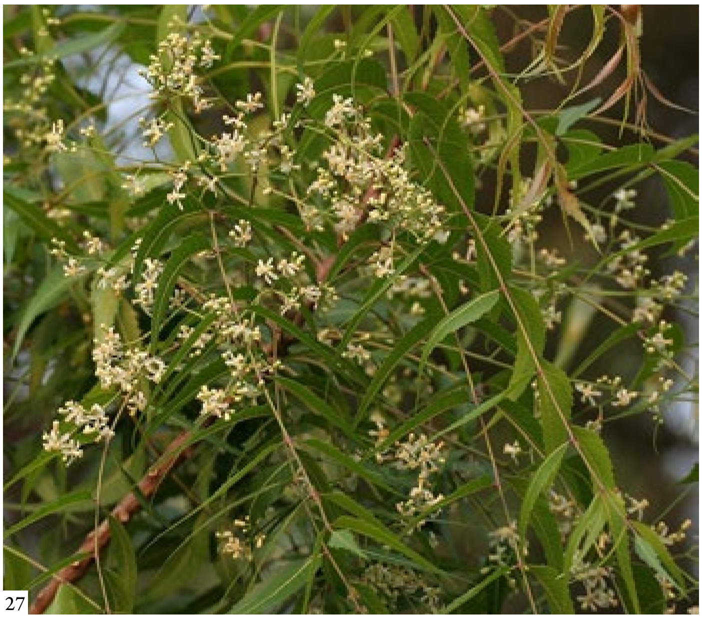
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Figure 25: Flowers and fruit of the castor tree (The Spruce / Evgeniya Vlasova)

Figure 26: Fruit of the Indian bael (Niranjan Singh Solanki Indiamart)

Figure 27: Neem tree (J.M. Garg)

Conclusions

Our inventory of traditional Indian plasters and their natural ingredients was prompted by the rich and diverse knowhow in traditional practice and the importance of documenting this practice before it is lost to globalization and modernization. Our research has shown the extent of our ancestors' understanding of the balance of nature and of the natural resources around them. Thus most of the ingredients documented were found to be used not only in natural construction but also for medicinal and other purposes. Another point to note is that the ingredients used in traditional plasters depend greatly on the natural resources available. For example, the natural additive *kadukkai*, found widely in Tamil Nadu and Kerala in southern India, is not easily sourced in northern parts such as Rajasthan, which is why fenugreek is used as a substitute, given its similar properties in plaster. While such resource management and use of locally available materials is out of fashion in construction today, alternatives to the prevailing materials evidently do exist. Examples of the same principle can be found in Dharampal's *Indian Science and Technology in the Eighteenth Century*, whose detailed descriptions of lime mortar techniques used in Madras include suggestions for alternatives with similar properties that are more readily available in England.

Documentation and inventorying are just the first steps toward revival and adaptation. This paper opens up avenues for future research on a larger scale, suggesting a need for tests and feasibility studies regarding cost, availability of materials, preparation times, application times, maintenance requirements, and environmental impact. Scientific testing of these techniques and materials will be a step toward adapting and integrating them into current practice.

Through understanding these knowledge systems, with their practices and nuances, we can develop pathways toward sustainable, climate-friendly development. This may lead to place-adaptive solutions, local in terms both of materials and of skills and liable to become alternatives to today's high-carbon practices. Their revival will also restore traditional and indigenous livelihoods and cultures, allowing these traditions of natural building to be safeguarded and continued.

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Biographies | Biografías | Biografias

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