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The Vibrant Palette of Ancient India: The Chemistry of Colors

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Abstract

Ancient Indian artisans crafted stunning hues for textiles, murals, pottery and body art using natural minerals, plants and insects. The colors, derived from natural mineral and organic sources, were deeply integrated into art, textiles, and ritual, with a palette dominated by white, yellow, red, black, and blue. These colors stemmed from inorganic and organic compounds, leveraging principles like electron transitions, coordination chemistry and resonance stability of pigments. The concept of color is as old as human civilization. From Vedic literature, it was found that the natural colorants were available to human from the ancient times. Pigments like red ochre, lapis lazuli, and indigo were used in cave paintings (Bhimbetka, Ajanta) and textiles, guided by ancient treatises such as the Vishnudharmottara Purana and Natyasastra. Our Indian Vedic literature gives many proofs regarding colour used in ancient times. The study of these pigments reveals an advanced understanding of material science, with many colors retaining their intensity for thousands of years, as seen in cave and temple murals. In this paper, we have selected some period from Vedic time to historic time regarding colour utilization. Also here is a breakdown of key colors, their sources and the underlying chemistry.

Introduction

Color has always been a large part of the Indian consciousness; in fact, it is ingrained in our DNA. This reverence for color stems from ancient Hindu philosophical beliefs, mythology, and historical events during colonial times. Transcending decorative values and emotional associations, Hinduism, a pure manifestation of nature, provides a spiritual meaning to almost every color. Each color holds a cultural, religious, traditional, and symbolic meaning which has been assimilated into Hinduism. India is a country steeped in religious traditions, and the powers and mythical lives of the Gods tell the story of the importance of color **[1].** Since ancient times, India has been home to a million interpretations of symbols and colors. The warm, bright, joyous colors of India connected to the stories and legends that bind its people, culture, and faiths have always mesmerized rulers, invaders, colonizers, and visitors. They offer kaleidoscopic insight into an almost perfect blend of collective history and individual modernism. The use and interpretation of color can vary by region, and colors portray unique emotions to people living in different regional, geographical, and religious areas. The affection of bright colour combination like vermilion (red) and yellow is inherent in the thought of the Indian people **[2].** The use of color in rituals

to express a particular idea stems from the Hindu belief about the nature of heat. In ritual, heat must be encircled by cooling things. White and red are the pivotal colors of this concept. Objects red in color symbolize a 'hot' state while white color signifies a 'cool' one. Thus, the red used in worship typically occurs against a background of white. Gender symbolism is also expressed through color. In Hindu weddings, the groom wears a cool white, and the bride wears a vivid red which again is associated with fertility. The colors known by the people of Vedic period seem to be proved from the references in the `Rig Veda' and `Atharva Veda'. One Rig-vedic verse speaks of seven rays (often interpreted as seven colours) associated with the sun's chariot: This describes the sun drawn by seven 'mares' or rays, which later commentators associate with seven prismatic colors. The Sanskrit sloka from **Rigveda 1.50.8:** along with English meaning are depicted below.

sapta yuñjanti ratham eka-cakram
eko aśvo vahati sapta-nāmā |
tri-nābhi cakram ajaram anarvaṃ
yatremā viśvā bhuvanāni tasthuḥ ||
It means:

"Seven harness the one-wheeled chariot;

one horse, having seven names, draws it.

The wheel has three hubs, is undecaying and unbroken;

on it all the worlds stand."

This verse is traditionally interpreted as referring to the Sun, with:

"sapta yuñjanti ratham" – "Seven yoke the chariot", where the seven rays of the Sun yoke or set the solar chariot in motion. These seven rays are the basis of seven colors.
"ratham eka-cakram" – "the chariot with one wheel" which means the one wheel represents time, especially the solar year (saṃvatsara). Though days and months appear many, time is one continuous cycle.

"eko aśvo vahati sapta-nāmā" – "One horse with seven names draws it" Here one horse means the Sun itself or the solar energy.
"sapta-nāmā" – "having seven names" It can be explained like this: the Sun being known by seven appellations, often linked to the seven rays, The "horse" here is symbolic of speed and power.
"tri-nābhi cakram" – "the wheel has three naves (hubs)" The three hubs are past, present, and future,

"ajaram anarvaṃ" – "undecaying and unbroken" which means Time and the Sun's course are eternal and uninterrupted. All existence depends on the Sun's movement. Without the Sun, the world-system cannot function.
"yatrema visva bhuvanani tasthuḥ" – "on which all these worlds are established". It actually hints about the Galaxy where more than one world coexists.

In Atharva Veda we can see the clear cut reference and manifestation of different colors. The Sanskrit sloka from **Atharva-Veda VI.83.2** along with English meaning are given below.

citra sweta kṛiṣṇa rohiṇyau cha ye |

tasaṃ namani vedaham ||

It means:

“One is variegated, one is white, one is black, and two are red:

I have gotten the names of all of them.”

This is a translated line from Atharva-Veda where colors are explicitly mentioned.

Citra – variegated / multicolored

Sweta – white

Kiṛṣṇa – black

rohiṇyau – the two reddish (or blood-coloured) forms

This hymn belongs to a healing charm in the Atharva-Veda, where different colors of disease or affliction are named and ritually neutralized. The verse shows that explicit colour terminology is clearly present in the Atharva-Veda. The context of the hymn is a charm for curing scrofulous sores, and the seer lists various colors of the affliction/sores as part of the incantation. Another well-known Atharva-Veda chant (**Atharva-Veda 1.23.1)** that explicitly mentions three colors - dark (śyāma), yellow (pīta), and red (aruṇa / aruṇimā) occurs in the fever (takman) hymns, where disease is described by colour.

Syama te tanuḥ peetah aruṇa casi takman |
ava tvā yami harasa ||

It means:

“O Fever (Takman), your form is dark,
yellow, and also red.
With force, I drive you away.”

This verse belongs to Atharva -Vedic healing charms where colors are used to classify manifestations of illness (different symptoms or stages). Naming the colors was believed to give ritual control over the disease. In this chant three colours i.e (shyam varna) dark colour, (peeta) yellow and (arunim) red colour are mentioned. Even in our sacred epics, The Ramayana and The Mahabharata, we get a number of references regarding color. It is said that in the coronation ceremony of Shri Ràma, white colour things were used i.e. white flower garland, white flag, and white umberella. Also in Sri Ramcharitmanas

(Kiskindha-Kand), while describing the body structure of Sri Rama, author Goswami Tulsidas compared the body colour of Sri Rama with dark blue colored lotus **[3].**

नीलोऽपल तन स्याम काम कोटि सोभा अधिक।

This means
“Listen to the praises of Sri Rama,
Whose body is dark as a blue lotus.
Here dark blue lotus is a metaphor: This phrase literally means “having a dark (syama) body which evokes depth, infinity, purity, and the cosmic essence of the divine form. He also compared Sri Rama's eyes with of budding red colored lotus. The Ramayana also suggests that the wives of Ravana wore multicoloured clothes **[4].** In a parallel manner, the Mahabharata also suggests to printed cloths. The normal word for printed clothing is `Chitra Vastra'.

Every character of the Mahàbhàrata was recognized with a particular colour **[5].** Lord Sri Krishna wore yellow coloured clothes due to this reason he was also called `Pitàmbara' while his elder brother Balram wore blue coloured clothes so he was called Nilambara. Pitamah Bheesma always wore white colored clothes **[6].** Yudhisthira and Arjuna used to wear white robes and silver capped ornaments while Duryodhan and Bhima were liked to wear red colored clothes. Nakul and Sahdev wore yellow and blue colour clothes. If we talk about ladies garments, Kunti, mother of Pandavas wore white colored saree while Draupadi, wife of Pandavas, wore grey colored saree.

पीताम्बरधरं वासुदेवं
शङ्खचक्रगदाधरम्
This means
Vāsudeva, clad in yellow garments,
Bearing the conch, discus, and mace.

श्वेतवाससमर्जुनम्
श्वेताश्वयुक्तं रथम्
This means

Arjuna, clad in white garments,
Seated upon a chariot drawn by white horses.

Here white symbolizes purity, sattva, and heroism.

श्वेताम्बरधरं राजन् धर्मराजं युधिष्ठिरम्
This means

King Yudhiṣṭhira, the lord of dharma,
Clad in white garments.

Yudhiṣṭhira is consistently described as wearing simple white clothing, befitting a righteous king.

The Mahabharata does not always specify Bhima's clothes, but in battle descriptions he is associated with red hues (rage, blood, power).

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रक्तनेत्रो महाबाहुः

This means

The mighty-armed one with reddened eyes…

Even palace-color of Sri Krishna's wife was also mentioned in Mahabharata. It was said that Sri Krishna's second wife named Satyabhàmà always lived in white colored palace **[7].** All these references prove that colors aren't a modern invention – they trace their origins back to ancient India. And colors are not just decorative – they conveyed emotions and states of being (shakti/energy with red, calmness with blue), and were often tied to cosmic principles and social identity.

Philosophy behind chemistry of colors

The theory of colors according to the ancient Indians was rooted clear and comprehensively in the Sankhya-Patanjala system. As was known then, the theory was essentially metaphysical in concept which describes reality as a dualism of pure consciousness (Purusha) and primordial matter (Prakriti) with three qualities (Gunas) evolving in the world through interplay of these gunas which was the basis of Indian philosophy **[8].** In the Sankhya-Patanjali (Yoga) philosophical system, there is no separate "color theory" like in art or optics. Instead, color (rupa) is explained as part of a metaphysical and psychological framework—how perception arises from nature (Prakṛti) and its constituents. All experience, including color, arises from Prakṛti (Nature), which is composed of three guṇas **[9].** The traditional explanation is clarified below.

Guna	**Quality**	**Symbolic Color Associations***
Sattva	clarity, light, harmony	white, luminous, transparent
Rajas	activity, motion, passion	red, dynamic, fiery
Tamas	inertia, darkness, heaviness	black, dull, opaque

In the days of yore, color of the substances was explained on this philosophical basis. In ancient India, people was used to collyrium- an enchanting kohl-like-elixir-reigned supreme in beauty rituals and ophthalmic medication, captivating hearts with its timeless allure that endures vibrantly even today. One of the key ingredients of collyrium (known a surmah or kajal) was lead sulfide (PbS) for its antibacterial properties. When PbS is prepared by mixing equal parts of sulfur (S) and lead (Pb) in a 1:1 stoichiometric ratio in solid state at high temperature, the resulting compound is black sulfide of lead PbS.

$Pb + S \rightarrow PbS.$

white yellow Black

According to Indian philosophy, lead and sulfur contain sattva, rajas and tamas in different proportions. Depending upon the relative strengths of each element, color of the product compound predominates. So the black color of PbS reveals the domination of Tamas. During the formation of black sulfide of lead, the silver white lead and yellow sulfur when mixed together would give a yellowish white mixed color but, in the particular allocation, the Tamas of the lead becomes dominant over Sattva and Rajas. Whereas during the formation of red cinnabar mercurous sulfide (HgS), the same components due to the predominance of Rajas gives red coloured mercurous sulfide.

$Hg + S \rightarrow HgS.$

white yellow Red

How old is the art of dyeing

The art of dyeing was as old as human civilization. From the historical records, it is learnt that natural colorants were available to people during Greco-Roman periods **[10].** Our Vedas, the Atharva Veda carries description of natural dyes. The use of natural dyeing materials is evident with the wall paintings of Ajanta, Ellora and Sittannvasal and they still demonstrate the efficacy of dyeing craft that had been inherited from ancient times in India. The incredibly preserved frescoes of Jain cave temple of Sittannvasal are some of India's earliest examples of Jain mural paintings. Ever since primitive people could create, they have been endeavoring to add color to the world around them. They used natural matter to stain hides, decorate shells and feathers, and paint their story on the walls of ancient caves. Scientists have been able to date the black, white, yellow and reddish pigments made from ochre used by primitive man in cave paintings to over 15,000 BC. Natural dyes have been used since ancient times for coloring and printing fabrics. Until the middle of last century, most of the dyes were derived from plants or animal sources by long and elaborate processes. Among these Indigo, Tyrian purple, Alizarin, Cochineal and Logwood dyes deserve special mention. Tyrian purple is a deep rich reddish purple historically derived from sea snails, symbolizing royalty in ancient times. Whereas the cochineal dye produces a vibrant red pigment extracted from the cochineal insect, historically used in textiles and cosmetics **[11].**

Ancient Indian Sanskrit grammarian Pànini referred numerous dyes then recognized, the cloth dyed being named after the dye. 'Raga' signified both colour and dye stuff **[12].** If cloth was dyed red then it was known as 'Lohitaka', if dyed black then it was known as 'Kalaka'. One famous commercial dye 'Laksha' was produced in India from ancient times. Lacquer work was called 'Jatusha'. Madder (Manjishtha), indigo (Nila), and orpiment (rochana) were also referred as dyes. A cloth dyed in indigo was known as 'Nila'. Haridra and maharajana are mentioned by ancient Vedic grammarian Katyana as dye stuffs. **3** Paṇini did not describe dyeing techniques like master mind Kauṭilya. Instead, he recorded dye-terms as living vocabulary, which shows that these dyes were well established in society before his time (5th–4th century BC). In `Arthsastra', Kautilaya described three types of shawls. In every type of knitting of shawl either by cotton, wool or silk, he also mentioned three colors i.e white, blue, and yellow. Kautilaya also mentioned the tree bark colour in his book. It is said that bark of `nagvrikshika' is of yellow colour while bark of `likuch' and `bakul' tree are of golden and white colour. Bark of 'Somavalka' and 'Arjuna' trees are of white colour like butter. Kauṭilya did mention dyes and dyeing in the Arthasastra, mainly in Book (Adhyakṣa-pracara), especially in chapters dealing with textiles, state

workshops, trade, and fraud prevention. These verses are administrative, not poetic, so they are usually short and technical **[13].**

नीलमञ्जिष्ठालाक्षाहरिद्रारक्तवस्त्राणाम्
उत्पादनं विक्रयं च पर्यवेक्षेत्।
This means

The superintendent shall supervise the production and sale of textiles dyed with indigo (nila), madder (manjiṣṭha), lac (lakṣa), and turmeric (haridra).
Eminent grammarian Pāṇini's rules allow formation of ranjaka – dyer whereas ranjana – dyeing. This proves dyeing as a specialized profession and a stable economic activity before Mauryan times.

Even in Sage Bharata's Natyasastra, the great Sanskrit treatise on the performing arts, we get clear classification of four primary colors—white, yellow, red, and dark blue—and their combinations for theatrical make-up. There is a clear english rendering of Nāṭyaśāstra, Chapter 21, verses 78B–87A, which deals with colors (varṇa), their nature, and their application in dramatic representation, especially aṅgavartanam (bodily movement, makeup, and visual depiction).

Sweto, nilas cha pitas cha chaturtho rakta eva cha
Ete swabhavaja varna yaih karyam tav angavartanam

Natya shastra 21.78B-87A

This means
White, blue, yellow, and the fourth is red.
These colors, by their very nature, are to be applied in bodily representation (movements/expressions).

Besides in Vishnudharmottara Purana, famous for its encyclopedic covering of wide range of topics in traditions of Hinduism, we find lists of five primary colors (Sveta, Pita, Vilohita, Krishna and Nila) for creating various shades in painting. Here symbolism is mentioned where deep reds and ochres symbolized power, status, and spirituality, while indigo was a prominent trade commodity.
A small stone sculpture with a cloak thrown over the left shoulder referred as the `Priest-King' is one of the most well known example of a textile from the site of `Mahanjo-daro' **[14].** When the sculpture was first explored, the trefoils and circles were filled with red pigment and the background was filled with a dark pigment that may have initially been green or blue. The original stone of white colour would have been visible in the form of circle, resulting in a striking pattern made of green or blue with red and white designs. Pattern of this type using indigo, madder, and bleached cotton is still normally used in the printing of ajrakh black prints in modern Sindh, Gujrat, and Rajisthan. Terracotta marionette from the crucial Neolithic archaeological site of Mehrgarh and the nearby site of Nausharo in Balochistan, Pakistan include ladies marionette with elaborate headdresses and gents' marionette with pantaloons and turbans. The black painted designs on some turbans may illustrate black goat's wool or deep indigo dye was utilized to make ornamental woven bands **[15].**
No exploration of color's splendor in ancient India stands complete without weaving in the Mughal era's luminous threads. Mughal era is well known for its ornamental art and intricate precision of designing

and placement of motifs which were practiced on textiles and architectonic constructions in Mughal period.

Mughal artists utilized a rich and vibrant palette of natural colors sourced from minerals, plants, and even precious metals. These pigments were meticulously prepared and used in paintings, textiles, and architecture not just for aesthetics, but also for their symbolic meanings **[16].** Artists ground stones and minerals into fine powders on stone slabs, and then mixed them with water and a binder like gum Arabic to create paint. They also used vegetable dyes which were extracted from various plants. For example, red dye could come from the bark of the peepal tree, and blue dye (indigo) was sourced from the Indigofera plant. Precious Materials such as gold and silver were also incorporated, often as a powder mixed into the paint or dusted onto the surface, to represent wealth and status and create shimmering effects. They used naturalistic floral motifs, stylized floral motifs and abstract motifs. Motif is an element of pattern, picture, or part of one or more ideas. Islamic geometrical motifs were based on constructive polygons such as hexagon and octagon. Natural motifs are inspired from nature including flower leaves, birds and animals embroidered on disparate garment very close to natural designs and motifs. Stylized motifs lose its original form as it becomes more ornamental and stylized. In abstract motifs only textures, colour, patterns used to copy from natural species. The most eminent Mughal motifs were iris and narcissus flowers commonly utilized in the borders with tulips, red roses and lilies. Kashmir shawls were the main garment examples of floral motifs. In the period of Emperor Jahangir, floral printed pyjamas were also noticed **[17].** It was mentioned in Klingelhofer's work (1980) that Akbar's Tomb at Sikandra was decorated with the combination of four-tiered red sand stone topped with a white marble pavilion..3 Features have a complex geometric, floral and calligraphic patterns, with a high entrance gate that predates the Taj Mahal.

Chemical aspects of colors in ancient India

In ancient India, colors were not only aesthetic or symbolic but also based on empirical knowledge of natural chemistry. Artisans, dyers, painters, and ritual specialists understood how to extract, process, fix, and preserve pigments and dyes from minerals, plants, and animals. There were three major sources of colors. They are:

i) Mineral based pigments (mainly of Inorganic Chemistry)

White color was obtained from quick lime CaO and slaked lime $Ca(OH)_2$ which were produced by heating sedimentary rock lime stone ($CaCO_3$). Besides, gypsum ($CaSO_4.2H_2O$) occurred in extensive beds from ocean brine evaporation. $CaCO_3 \rightarrow CaO + CO_2$

Red color was obtained from Red ochre (geru) and cinnabar. Red ochre is a natural earth pigment primarily composed of hematite (Fe_2O_3) and magnetite or ferrosoferric oxide (Fe_3O_4). Cinnabar is a bright scarlet to brick red mineral containing mercurous sulfide (HgS). Ferrosoferric oxide (Fe_3O_4) is a mixed oxide which contains both ferrous and ferric oxide. $FeO + Fe_2O_3 \rightarrow Fe_3O_4$

Yellow color was obtained from Yellow ochre and orpiment. Yellow ochre is a natural earth pigment consisting mainly of limonite, a hydrated iron oxide. It features iron (III) oxy hydroxide ($FeO(OH).nH_2O$ as the primary colorant . Heating transforms it to red ochre by dehydrating to hematite. Arsenic sulfide (As_2S_3) also known as orpiment, a yellow mineral compound used historically as a pigment.

Blue color was obtained from Lapis lazuli and azurite. Lapis lazuli is a deep blue metamorphic rock primarily composed of lazurite, which is a tectosilicate mineral comprising of sodium aluminosilicate framework with variable sulfur/chloride/sulfate ions that produce its vivid blue color. Azurite is a vibrant blue copper mineral which is actually a basic copper carbonate $CuCO_3$,$Cu(OH)_2$

Black color was obtained from lamp black, described as being soot collected from the surface of burning oil lamps. Kajal was likely a form of lampblack. Soorma was a second type of black pigment whose major component was antimony sulfide (Sb_2S_3). Indian art predominantly features black, carbon-based pigments like lampblack, kernel black and charcoal. These pigments were chemically stable, which is why many ancient murals still retain color.

ii) Plant-based dyes (Mainly of Organic Chemistry)

Natural dyes or plant based dyes are not new especially for Indian culture. It is an ancient craft rich in history and tradition. The first colors used for textile were probably little more than stains. Bright yellows and yellows oranges from turmeric, saffron and annatto; and pinks and rose pinks from safflower were undoubtedly used quite early. People used these dyes directly, without any chemical processing, as crude mixture of colors. The comprehensive details of the dye-including the source, active compounds, and uses of plant based dyes-are provided below.

Red Dye	**Plant Source**	**Active Compound**	**Uses**
Madder (Manjiṣṭhā / Rubia cordifolia)	Roots of madder plant	Alizarin, Purpurin	textile dyeing (cotton, silk, wool), body coloring, ritual painting
Safflower (Carthamus tinctorius)	Petals	Carthamin	Textile dyeing, cosmetics
Hibiscus	Flowers	Anthocyanins	Temporary coloring of cloth or hair
Henna (Lawsonia inermis)	Leaves	Lawsone	Hair dye, hand-body decoration, ceremonial use
Yellow Dye	**Plant Source**	**Active Compound**	**Uses**
Turmeric (Haridra / Curcuma longa)	Rhizome	Curcumin	Textile dyeing, food coloring, medicinal and ritual use
Indian Madder / Manjistha (also yields yellow under certain treatments)	Roots	Alizarin derivatives	Mixed dyes for lighter shades
Pomegranate rind	Fruit peel	Tannins + flavonoids	Textile dyeing, mordanting for yellows
Blue Dye	**Plant Source**	**Active Compound**	**Uses**

Indigo (Nīla / Indigofera tinctoria)	Leaves	Indigotin	Textile dyeing, wall paintings, ink production
Woad (Isatis tinctoria)	Leaves	Indigotin	Rarely used; more common in North-Western regions
Brown and Black Dyes	**Plant Source**	**Active Compound**	**Uses**
Catechu / Khair (Acacia catechu)	Heartwood	Catechin & Epicatechin	Textile dyeing, black ink, leather coloring
Myrobalan (Haritaki / Terminalia chebula)	Fruit	Hydrolysable Tannins	Mordant and dark shades in textiles
Tea / Coffee extracts	Leaves / beans	Caffeine & Polyphenols	Minor use in modern historical reconstructions
Green Dye	**Plant Source**	**Active Compound**	**Uses**
Turmeric + Indigo	Rhizome + leaves	Curcumin + Indigotin	Textile dyeing (layered over)
Orange dye	**Plant Source**	**Active Compound**	**Uses**
Marigold (Tagetes spp.)	Flowers	Carotenoids	Textile dyeing, ceremonial decoration

In addition some other less frequent plant-based colors were also used in textiles in historic time in India.. The ingredients used were Amla (Indian gooseberry) for pale yellow color, pomegranate bark for yellowish-brown color and cutch or kaththa for brown black color. This proves that plant-based dyes in ancient India reflect deep knowledge of botany and chemistry. Dyers understood which plants yield which color, how to fix and modify colors and the interplay of mordants and natural pigments. Mordanting was one of the dyeing techniques where common alum, copper salts were used as mordants to fix dyes and to modify shades. Many of these dyes are still used in traditional Indian crafts**,** showing the continuity of ancient techniques.

Traditions of using natural colors in Folk paintings

Worldwide folk painting traditions and especially in India have long relied on natural colors derived from plants, minerals, eartha and insects for their vibrant enduring hues. These pigments, mixed with natural binders like tree gum or animal fat, reflect cultural reverence for nature and sustainability. Cave paintings at Bhimbetka used red and white color from hematite and lime stones, with green and yellow from vegetable juices or charcoal blended with spit or fat for adhesion **[18].** The rich cultural diversity of India is reflected in the folk art and crafts. The folk arts of India are very simple, and yet vibrant enough to speak volumes about the country's rich heritage. Various painting styles are prevalent across various regions, each representing tradition and customs passed on from one generation to other. Traditionally, most of the Indian painting styles existed as wall paintings or murals. In due course of time, urbanization brought these painting forms on paper, canvas, and cloth etc. The themes were curtailed so as to fit into the smaller canvas. Preparing the paints is perhaps the most important part of the creation of folk

paintings, engaging the craftsmanship of the artists in using naturally available raw materials to bring about indigenous paints **[19].**

Phad Painting of Rajsthan

In Phad art of Rajasthan a majority of the colours used in this painting are of mineral origin. The colours are prepared with powdered minerals and semi-precious stones mixed with tree gum (Babul tree) – kheriya gond (indigenous glue) as a binding medium. This tree gum gives a dazzling brilliance and permanency to the painting.

Bengal Patachitra & Santhal Painting of West Bengal

Traditionally the Patuas of West Bengal make effective use of eco-friendly colors by collecting them from leaves, fruits, flowers, plants, trees and other natural elements. For instance, Bengal's Patuas extract red from Annatto fruit or beet root, saffron yellow from Lotkon leaves, blue from Aparajita flowers (Neelkanth flower), brown from Segun tree, yellow from turmeric, black from lamp black or charcoal, green from Ivy gourd (kunduri or telakucha) (also from Babal tree), white from Kusum Mati or rice powder etc. The colors are blended with natural gum of wood apple to provide the glaze or coherence to the base **[20].**

Pattachitra Art of Odisha

For preparing Odisha Pattachitra, artists of Odisha used a range of raw materials like vegetables, stones and minerals. In Odisha Pattachitra the gum of the kaitha (wood apple) tree is the chief ingredient, and was used as a base for making different pigments, on which diverse raw materials are mixed for diverse colors. All these colours are mixed in dried coconut shells.

Gond Painting of Madhya Pradesh

Colours used for Gond painting by Gond tribe (the largest tribes in Central India) on walls and floor are made from different kinds of soils and other organic things available in the village. For example, Gonds used wood coal for black, chhui soil or lime for white, red from red coloured soil called geru, yellow from pili mitti (available around the Narmada river). Certain colours have special significance and are used to depict specific emotions and elements. Fine dots, lines and dashes are used to create the images in Gond art. The minute infilling of the motifs is a significant characteristic of Gond art.

Madhubani Painting of Bihar

The Madhubani artists of Bihar made colors from plant extracts; for example, white from rice powder, yellow was prepared from turmeric, lamp soot was used for a black pigment, orange from the Palasa flower, red from Kusum flowers or red sandalwood, blue from indigo, and green from the wood apple leaf. These juices were mixed with resin from banana leaves and ordinary gum to enable it to stick to the painting medium. Some colors were mixed with a paste of cow dung to have a better texture. Thus folk painting in ancient India represents a timeless bridge between spirituality, community and the natural world, evolving from prehistoric rock art to intricate regional styles that encoded myths rituals and daily life. Embeded in festivals and temple walls, they fostered social cohesion and devotion, influencing modern revivals while preserving ancient techniques and globalization.

Conclusion

India is truly a land of many colors, everything ranging from clothes, jewelry and monuments are incomplete without colors. In ancient times, India was a very rich culture in the aspect of production and use of natural colors. In India natural pigments and dyes have been used to colour the fabrics and art works. Even at a site as old as Mohenjo-Daro, a 5000 year old scrap of madder dyed cloth was excavated. It's obvious from the above discussion that knowledge of colour was as old as our Vedas. From the records, it is seen that natural colorants were available to people from the Vedic times. In the early Vedic period, there were not practiced techniques of dyes but colour was recognized due the existence of natural colorants. With the development of civilization, weaving of clothes was considered to be a very needful job. Generally people wanted to make their garments beautiful for which it was important to make attractive designs on them. Due to this reason, dyeing portrayed a crucial character. This review highlights the complexity of understanding historical colors and pigments, focusing on their characterization, sources, and application in wall paintings and daily lives. It discusses the Ajanta wall paintings, noting that past and current investigations have only scratched the surface. The dissemination of ideas along ancient trade routes influenced the sharing of painting materials and techniques, but each wall painting remains unique. In this review work the emotions with colors have also been mentioned. Colors in Hinduism carry deep symbolic meanings tied to emotions, deities and spiritual states, influencing moods and rituals. Ancient Indian traditions linked colors deeply to emotions through the philosophical frame work of three gunas- Sattva, Rajas and Tamas, as stated earlier. Red embodied Rajas, evoking love, passion, anger, power and sensuality and is exceptionally significant in the Hindu religion. It's the color of life and in felicitous occasions like weddings, festivals, childbirth, and general auspiciousness. Brides wear red on their wedding day, put red sindur on their hair, and place a red dot or Kumkum on their foreheads to signify purity, sensuality, and fertility. Gods depicted in red are charitable, generous, brave, and protective and can destroy evil. Whereas saffron robes are denoted for ascetics renunciation and inner fire. It is also associated with deities like Vishnu and Ganesha. The natural world is green and suggests peace, happiness, purity, and harmony that the Gods bring to our world. Blue represents infinity, spirituality peace and energy supply to the aura, connected to Vishnu and complex divine qualities. Gods like Rama, Krishna and Shiva, are also shown with blue skin, representing calm and stable mind, manifesting the qualities of bravery, manliness, determination, and the ability to deal with challenging situations. The color green represents fertility, life, and rebirth found in nature. The color is easy on the eyes and stabilizes the mind. White is a mixture of seven different colors; hence it personifies the quality of each: purity, cleanliness, peace, and knowledge. It is diametrically opposite to red. Saraswati, the Goddess of Knowledge, is always shown wearing a white dress and sitting on a white lotus. White signifies sattva- goodness serenity, purity and contentment – while promoting emotional balance. It is also symbolic of the loss of life in Hinduism. White is the absence of color and repels all light and colors and, as such, is the acceptable color at ceremonies that mark a death in the family. Hindu widows wear white in grieving as it represents their need to detach themselves from the pleasure of participation in society and give back to the world. Black signified Tamas, conveying negativity, inertia, denial, death and darkness linked to misfortune. This scholarly article draws from Vedic texts and archaeological finds to reveal how hues symbolized life's spectrum-from passion to purity-shaping societal expressions.

References

1. Murthy H. V, A critical study of upanayana samaskàr. (1997), 99.
2. Sri Vishnu Sahasaranàma Stotram', `Dhyànam' 5 sloka.
3. Tulsidas, Sri Ràmcharitmànas, Motilal Banarsidass Publishers Pvt.Ltd.
4. Sharma D. P, Srimad Vàlmãki Ràmàyan, `Ayodhayàkànda' 02, (1927), Tritiya sarg 9-10.
5. Sàrda Radhika, Kumar Rajeev, `The Costumes Of Mahabharat: (2017), 294-296
6. Ramnarayan Dutt, Mahabharat, `Arghabhiharan Parv', Gita Press Gorakhpur, Chapter 28, 712
7. Ramnarayan Dutt, Mahabharat, `Sabhà Parv', Gita Press Gorakhpur, Chapter 28, 714.
8. Sāṅkhya Kārikā of Īśvarakṛṣṇa: Kārikās 12–13
9. Pātañjala Yoga, Samādhi Pāda (Chapter 1)
10. Punia Ritu, Dyeing in ancient Indian textile: An analytical study. Ascent International Journal for Research Analysis (AIJRA), (2015), 3(1), 1-6
11. Burman Roy B. K, `Monograph Series, Textile Dyeing and Hand- Printing in India', (2016), Vol-I. Part VII-A (iii),
12. Agarwala V.S.India as known to Panini', Economic conditions, Art and crafts, (1953), 230-231.
13. Kautilaya, `Arthshàstra', Chapter-11, 171.
14. Kenoyer, Mark Jonathan.“Ancient Textiles of the Indus Valley Region.” (1998)
15. Tana Bana: The Woven Soul of Pakistan. Karachi: Textile Institute of Pakistan, (2004), pp. 18–31.
16. Jamil Farah, Gulzar Saima, `Historical Development Of Dado Ornamentation In Mughal Architecture', Structural Studies, Repairs and Maintenance of Heritage Architecture XV, 171, (2017), 97.
17. Kumari, Annu. “Elucidation of the Relationship between Clothing Silhouette and Motifs with Indian Mughal Architecture.” Fashion and Textiles, 6(1), 2019, pp. 1–23.
18. Sharma, A., Singh, M.R., 2021. A Review on Historical Earth Pigments Used in India’s Wall Paintings. Heritage. 4(3), pp 1970–1994.
19. Nardi, I. The theory of Indian painting: The citrasutras their uses and interpretations. University of London, School of Oriental and African Studies (2003). 10673055.
20. Dabhade, S.B. Technique of wall painting in ancient India. University of California (1973) Page 1–48

References

[1]

[2] Kumar, A., Dixit, U., Singh, K., et al., 2021. Structure and properties of dyes and pigments. In Dyes and pigments-novel applications and waste treatment. IntechOpen.

[3] Diacu E., 2016. Colours: Properties and Determination of Synthetic Pigments. Encyclopaedia of Food and Health, 284–290.

[5] Singh, M., Arbad, B.R., 2012. Conservation and restoration research on 2nd BCE murals of Ajanta. International Journal of Scientific and Engineering Research. 3(10), 1–8.

[6] Ballinarno, P., Maras, A., 2006. Mineralogical characterization of the blue pigments of Michelangelo's fresco "The Last Judgement". American Mineralogist. 91, 997–1005.

[7] Gottesman, S., The 6,000-Year History of Blue Pigments in Art. Artsy. November 29, 2016 Accessed April 25, 2021 https://www.artsy.net/article/artsy-editorial-a-brief-history-of-blue

[8] [9] Plesters, J., 1993. Ultramarine blue, natural and Artificial In: Roy, A. (eds.). Artists' Pigments: A Handbook of their history and characteristics, volume 2. National Gallery of Arts, Washigton D.C., pp.37–65.

[10] Yusuf, M., Shabbir, M., Mohammad, F., 2017. Natural colorants: Historical, processing and sustainable prospects. Natural products and bioprospecting. 7, 123–145.

[11] Parikh, K., 2011. Colour symbolism: Emotional values of colour. Indian Journal of Applied Research. 3(1), 65–66.

[12] Singh, M., Arbad, B.R., 2013, August. Architectural history and painting art at Ajanta: Some salient features. Arts. 2(3), 134–150.

[13] Wyart, J., Bariand, P., Filippi, J., 1981. Lapis-lazuli from Sar-e-Sang, Badakhshan, Afghanistan. Gems & Gemology. 17, 184–190.

[14] Singh, M., 2011. Microclimatic condition in relation to conservation of cave no. 2 murals of Ajanta. Current Science. 101(1), 89–94.

[15] Sharma, A., Singh, M.R., 2020. Multi-analytical investigation of the composition and binders used in the earthen support layer of fifth–fourteenth century CE painted fragments from Bezeklik, China. Studies in Conservation. 65(4), 221–237.

[16] Ju, W., 2022. The Research on the Origin and Communication of Blue and Green Colors in Chinese Blue and Green Landscape Painting. Journal of Education, Humanities and Social Sciences. 5(2022), 119–125.

[17] Shui, B., Yu, Z., Cui, Q., et al., 2022. Blue pigments in Cave 256, Mogao Grottoes: a systematic analysis of murals and statues in Five dynasties, Song Dynasty and Qing Dynasty. Heritage Science. 10(1), 1–12.

[18] Aoki, S., Taniguchi, Y., Rickerby, S., et al., 2021. Conservation and Painting Techniques of Wall Paintings on the Ancient Silk Road. Springer: Singapore. Cultural Heritage Science, ISBN 978-981-33-4160-9 ISBN 978-981-33-4161-6 (eBook)

[19] Orna, M.V., Fontani, M., 2022. The modernity of ancient pigments: a historical approach. Colorants, 1(3), 307–346.

[20] Booth, D.G., 2002. The synthesis and structure of Ultramarine Pigments (Doctoral dissertation). University of Southampton Institutional Repository.

[21] Nečas, R., Všianský, D., 2016. Ultramarine–not just a pigment of traditional folk architecture plasters. Procedia Engineering. 151, 114–118.

[22] Chukanov, N.V., Sapozhnikov, A.N., Shendrik, R.Y., et al., 2020. Spectroscopic and crystal-chemical features of sodalite-group minerals from gem lazurite deposits. Minerals. 10(11), 1042.

[23] Schmidt, C.M., Walton, M.S., Trentelman, K., 2009. Characterization of lapis lazuli pigments using a multitechnique analytical approach: implications for identification and geological provenancing. Analytical chemistry. 81(20), 8513–8518.

[24] Favaro, M., Guastoni, A., Marini, F., et al., 2012. Characterization of lapis lazuli and corresponding purified pigments for a provenance study of ultramarine pigments used in works of art. Analytical and bioanalytical chemistry. 402, 2195–2208

[25] Eaton, G.R., Eaton, S.S., Stoner, J.W., et al., 2001. Multifrequency electron paramagnetic resonance of ultramarine blue. Applied Magnetic Resonance. 21, 563–570.

[26] Rejmak, P., 2018. Structural, optical, and magnetic properties of ultramarine pigments: A DFT insight. The Journal of Physical Chemistry C. 122(51), 29338–29349.

[27] Cato, E., Rossi, A., Scherrer, N.C., et al., 2018. An XPS study into sulphur speciation in blue and green ultramarine. Journal of Cultural Heritage. 29, 30–35.

[28] Laurie, A.P., 1926. The painter's methods and materials. J.B. Lippincott Company: Philadelphia, PA, USA pp. 249 pages, Courtesy of Science History Institute

[29] Plesters, J., 1966. 2. Ultramarine Blue, Natural and Artificial. Studies in conservation, 11(2), 62–91.

[30] Frison, G., Brun, G., 2016. Lapis lazuli, lazurite, ultramarine ‘blue’, and the colour term ‘azure’up to the 13th century. Journal of the International Colour Association. 16, 41–55.

[31] Ganio, M., Pouyet, E.S., Webb, S.M., et al., 2018. From lapis lazuli to ultramarine blue: Investigating Cennino Cennini's recipe using sulfur K-edge XANES. Pure and Applied Chemistry. 90(3), 463–475.

[32] Arieli, D., Vaughan, D.E., Goldfarb, D., 2004. New synthesis and insight into the structure of blue ultramarine pigments. Journal of the American Chemical Society. 126(18), 5776–5788.

[33] Osticioli, I., Mendes, N.F.C., Nevin, A., et al., 2009. Analysis of natural and artificial ultramarine blue pigments using laser induced breakdown and pulsed Raman spectroscopy, statistical analysis and light microscopy. Spectrochimica Acta Part A: Molecular and Bimolecular Spectroscopy. 73(3), 525–531.

[34] Verri, G., 2009. The spatially resolved characterisation of Egyptian blue, Han blue and Han purple by photo-induced luminescence digital imaging. Analytical and bioanalytical chemistry. 394(4), 1011–1021.

[35] Compendium, P., 2008. A Dictionary and Optical Microscopy of Historic Pigments Elsevier/Nicholas Eastaugh [et al.]. London and New York: Routledge Taylor&Francis Group, 950.

[36] Artioli, D., Capanna, F., Giovagnoli, A., et al., 2008. Mural paintings of Ajanta Caves, part II: Non-destructive investigations and microanalysis on execution technique and state of conservation. Proceedings of The 9th International Conference on NDT of Art; 25–30 May 2008; Jerusalem, Israel. pp. 25–30.

[37] Giovagnoli, A., Capanna, F., Ioele, M., et al., 2008. The mural paintings of the ajanta caves, part I: documentation on execution techniques and conservation condition. Art 2008-Non-destructive investigations and microanalysis for the diagnostics and conservation of cultural and environmental heritage. Page 1–10

[38] Cacace, C., Giani, E., Giovognoli, A., et al., 2008. The mural paintings of cave 17 in Ajanta: the environmental study and the geographic information system (GIS) of the collected data. In ICOM Committee for conservation conference, 2, New Delhi, pp. 726 to 734.

[39] Brill, T.B., 1980. Light: its interaction with art and antiquities. Springer Science & Business Media: Publisher:Springer US. pp. 1–287.

[40] Coccato, A., Moens, L. and Vandenabeele, P., 2017. On the stability of mediaeval inorganic pigments: a literature review of the effect of climate, material selection, biological activity, analysis and conservation treatments. Heritage Science. 5, 1–25.

[41] Cosentino, A., 2014. Identification of pigments by multispectral imaging; a flowchart method. Heritage Science. 2(1), 8.

[42] Bruce, H.D., 1928. Tinting strength of pigments. Bureau of Standards Journal of Research.Vol. 1, 125–150.

[43] Barsan, M.M., Butler, I.S., Gilson, D.F., 2012. High-pressure resonance Raman spectroscopic study of ultramarine blue pigment. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy. 98, 457–459.

[44] Clark, R.J., Cobbold, D.G., 1978. Characterization of sulfur radical anions in solutions of alkali polysulfides in dimethylformamide and hexamethylphosphoramide and in the solid state in ultramarine blue, green, and red. Inorganic Chemistry. 17(11), 3169–3174.

[45] Clark, R.J., Franks, M.L., 1975. The resonance Raman spectrum of ultramarine blue. Chemical Physics Letters. 34(1), 69–72.

[46] Ostroumov, M., Fritsch, E., Faulques, E., et al., 2002. Etude spectrometrique de la lazurite du Pamir, Tajikistan. The Canadian Mineralogist. 40(3), 885–893.

[47] Paramasivan, S., 1938. Technique of the painting process in the temple of Vijayalaya Cholisvaram in the Pudukkottai State. Proceedings of the Indian Academy of Sciences-Section A. 7(4), 282–292.

[48] Paramasivan, S., 1937. Technique of the Mural Paintings in the Brihadeswara Temple at Tanjore. Current Science, 6(6), 289–290.

[49] Gettens, R.J., 1938. The materials in the wall paintings from Kizil in Chi(nese Turkestan. Technical studies in the field of the fine arts. 6(4), 281–294.

[50] Brown, W.N. and Rowland, B., 1938. The Wall-Paintings of India, Central Asia, and Ceylon.Journal of the American Oriental Society, 58(3), 484–485.

[51] Rogala, D., 2014. Hans Hofmann's last lesson: a study of the artist's materials during the last decade of his career. In: van den Berg, K., et al. (eds.). Issues in Contemporary Oil Paint. Springer: Cham, Switzerland.

[52] Thompson, D.V., Berenson, B., 1936. The materials of medieval painting. CiNii Books, London, CRID: 1130000796799105280.

[53] Lal, B.; Ghosh, A., 1969, The Murals: Their Preservation; Gosh: New Delhi, India. pp. 56–59.

[54] Paramasivan, S., 1936. Technique of painting process in cave temples of Ajanta. Annual Report of the Archaeological, Highness the NizamVs Dominions.

[55] Bhardwaj, H.C. Some observations on the conservation of murals. In Proceedings of the Conservation of Cultural Property in India, New Delhi, India, 23–25 February 1966; pp. 37–46.

[56

[57] Singh, M., Arbad, B., 2013. Chemistry of preservation of the Ajanta murals. International Journal of Conservation Science. 4(2), 161–176.

[58] Sharma, D., Singh M., Krist, G., et al., 2020. Pigment analysis of palm leaf manuscripts of India. Current Science. 118(2), 285–292.

[59] Eastaugh, N. 2008, Pigment Compendium: A Dictionary and Optical Microscopy of Historic; Butterworth-Heinemann: Waltham, MA, USA.

[60] Kanth, A.P., Singh, M.R., 2019. Vibrational spectroscopy and SEM-EDX analysis of wall painted surfaces, Orchha Fort, India. Journal of Archaeological Science: Reports. 24, 434–444.

[61] Caggiani, M.C., Cosentino, A., Mangone, A., 2016. Pigments Checker version 3.0, a handy set for conservation scientists: A free online Raman spectra database. Microchemical Journal. 129, 123–132.

[62] Colomban, P., 2003. Lapis lazuli as unexpected blue pigment in Iranian Lâjvardina ceramics. Journal of Raman Spectroscopy. 34(6), 420–423.

[63] Al-Dabbas, M., Eisa, M.Y., Kadhim, W.H., 2014, Estimation of gypsum-calcite percentages using a Fourier transform infrared spectrophotometer (FTIR), in Alexandria Gypsiferous Soil-Iraq. Iraqi Journal of Science. 55(4B), 1916–1926.

[64] Reig, F.B., Adelantado, J.G., Moreno, M.M., 2002. FTIR quantitative analysis of calcium carbonate (calcite) and silica (quartz) mixtures using the constant ratio method. Application to geological samples. Talanta. 58(4), pp.811–821.

[65] Kanth, A.P., Singh, M.R., 2019. Spectroscopic and chromatographic investigation of the wall painted surfaces of an 18th century Indian temple, New Delhi. Vibrational spectroscopy. 104, 102947.

[66] Gettens, R.J., 1938. The materials in the wall paintings of Bamiyan, Afghanistan. Technical studies in the field of the fine arts. 6(3), 186–193.

[67] Delmas, A.B., Casanova, M., 1987. The lapis lazuli sources in the ancient east. South Asian Archaeology. 9, 393–426.

[68] Ji, J., Zhang, J.F., 2011. The Origin and History of Some Blue Pigments in Ancient China. Dunhuang Research. 2011(6), 09–14.

[69] Uda, M., Sassa, S., Yoshimura, S., et al., 2000. Yellow, red and blue pigments from ancient Egyptian palace painted walls. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms. 161–163, 758–761.

[70] Gettens, R.J. and Fitzhugh, E.W., 1974. Malachite and green verditer. Studies in Conservation, 19(1), pp.2-23.

[71] Szmelter-Fausek, B., Olszewska-Świetlik, J., 2016. Blue pigments in blue and purple painting layers of Gdańsks' paintings of the mid-16th to the end of the 18th century. Color Research & Application. 41(3), 270–275.

[72] Seldes, A.M., Burucúa, J.E., Maier, M.S., et al., 1999. Blue pigments in South American painting (1610–1780). Journal of the American Institute for Conservation. 38(2), 100–123.

[73] Sanz, E., Arteaga, A., García, M.A., Cámara, C., Dietz, C., 2012. Chromatographic analysis of indigo from Maya Blue by LC–DAD–QTOF. Journal of archaeological science. 39(12), 3516–3523.

[74] Tagle, A.A., Paschinger, H., Richard, H., Infante, G., 1990. Maya Blue: its presence in Cuban Colonial wall paintings. Studies in Conservation. 35(3), 156–159.

[75] Leona, M., Stenger, J., Ferloni, E., 2006. Application of surface-enhanced Raman scattering techniques to the ultrasensitive identification of natural dyes in works of art. Journal of Raman Spectroscopy. 37(10), 981–992.

[76] Liu, L., He, J., Ye, M., et al., 2019. Spectral characterization of pigment from the No. 1 cave, Kizil cave-temple complex. Journal of Spectroscopy. 2019(1), 1–9.

[77] Abe, Y., Harimoto, R., Kikugawa, T., et al., 2012. Transition in the use of cobalt-blue colorant in the New Kingdom of Egypt. Journal of Archaeological Science. 39(6), 1793–1808.

[78] Paramasivan, S., 1939. August. The wall paintings in the Bagh caves—An investigation into their methods. Proceedings of the Indian Academy of Sciences-Section A. 10, 85.

[79] Paramasivan, S., 1938. Technique of the Painting Process in the Kailasanatha and Vaikunthaperumal Temples at Kanchipuram. Nature, 142, 757.

[80] Yoo, S.Y., Seneviratne, B.J.N., Kim, G.H., 2022. A Characteristic Analysis on Clay Pigments of Mural Paintings in Sri Lanka. Journal of Conservation Science. 38(4), 327–333.

[81] Asiatic, 1912. The rise and fall of indigo industries in India. The Economic Journal. 22(86), 237–247.

[82] Aceto, M., 2021. Pigments—the palette of organic colorants in wall paintings. Archaeological and Anthropological Sciences, 13(10), 159.

[83] Nagpal, J.C. Mural Paintings in India; Gyan Publishing House: New Delhi, India, 1988; ISBN 8121201497.

[84] Lal U. S., Nair M. V., 2009. Scientific study of Pigments and Plasters of 12th century wall paintings of Lakhang- Gongma Monastery at Nako (H. P.). Conservation of Cultural property in India. 38(2009), 21–25.

[85] Bayerová, T., 2018. Buddhist wall paintings at Nako monastery, North India: changing of the technology throughout centuries. Studies in Conservation, 63(3),171–188.

[86] Gill, M.S., Rendo, C.P., Menon, S., 2014. Materials and techniques: early Buddhist wall paintings and sculptures at Sumda Chun, Ladakh. Studies in Conservation. 59(5), 300–313.

[87] Skedzuhn, A., Oeter, M., Bläuer, C., et al., 2018. The secrets of 14th century wall painting in the Western Himalayas: Structural damage sheds light onto the painting technique in the Tsuglag-khang in Kanji in Ladakh.

[88] Mazzeo, R., Baraldi, P., Lujan, R. et al., 2004. Characterization of mural painting pigments from the Thubchen Lakhang temple in Lo Manthang, Nepal. Journal of Raman Spectroscopy. 35(8–9), 678–685.

[89] Jaspal, N., 2017, Conservation of Wall Paintings at the Golden Temple(Sri Harmandar Saheb Ji), Amritsar, India. Available online: https://heritagepreservationatelier.com/2020/06/13/conservation-of-wall-paintings-at-the-golden-templesri-harmandar-saheb-ji-amritsar-india/ (accessed on 10 June 2021).

[90] Babel, S., Rajvanshi, R., Sharma, S., 2014. Mewar Paintings: An Exploratory Study. Asian journal of Home Science (AJHS). 9(2), 636–640.

[91] Agarwal, O.P., Tiwari, R.,Yadav, A. K., 1988. Examination of the Technique of Paintings at the Moghul Gateway, Bairat, Rajasthan and its conservation problems. Conservation of Cultural Property in India. pp. 21, 73–79.

[92] Agrawal, O.P., 1989, Examination and Conservation of Wall Paintings of Sheesh Mahal, Nagaur: A programme under National Project on Wall Paintings; NRLC. INTACH Conservation Center: Lucknow, India.

[93] Yadav, A.K.; Savita, R.P.; Singh, K.; et al., 1995, Conservation of wall paintings in Servent Chapel of St. Monica Church and Convent, Goa; INTACH Trust: New Delhi, India.

[94] Lal, G.; Singh, K.; Yadav, A.K. Conservation of Mural Paintings at Panchai Court, Imphal; INTACH: New Delhi, India, 1995.

[95] Agrawal, O.P. and Pandey, A.K., 1990. Scientific study of Kerala wall paintings. Conservation of cultural property in India, 23, pp.1–6.

[96] Mariyapillai, M., Paranthaman, G., Napoleon, K., et al., 2021. A re-reading on vibrant mural paintings of Sittanavasal cave temples. International Journal of Mechanical Engineering. 6(special issue, Nov.–Dec. 2021), 1619–1623.

[97] Agrawal O.P., Ram S. P., Mamta M., 1994. Conservation of Wall Paintings in India-Achievements and Problems (Proceedings of the Seminar Held During October 22–24, 1994),. Indian National Trust for Art and Cultural Heritage: New Delhi, India. pp. [vi] + 178.