

“Chemical Conservation Of Monuments”

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1. Introduction

Man made historical, cultural, religious and architectural important sites, which are more than hundred years old are termed as Historical Monuments. There are certain rules and regulations for declaration of monument and monumental zone as mentioned in “Ancient monument Preservation Act 2013 (including amendments) published by His Majesty's Government, Department of Archaeology, Nepal. Dhungedhara, Temples, Monasteries (Viharas, Bahal, Bahi), way side rest house (Patis, Pauwahs and Sattals), Stupas (chaityes), tank or Pokharis, Palaces, common man's house and forts etc. come under this heading. Such monuments give the historical information of the country and great person. Information about these things are either engraving or hand written on Golden plates, Copper plates, Stone slabs, Wooden objects, Birch barks, palm leaves, Parchments and papers etc. So, far His Majesty's Government of Nepal and UNESCO world Heritage Committee convened in Cairo in 1979, accepted and declared following sites to be enlisted in world Heritage and monument sites list.

1. Hanuman Dhoka Durbar Square
2. Patan Durbar Square
3. Bhaktapur Durbar Square
4. Swayambhu Nath Stupa
5. Bouddha Nath Stupa
6. Changu Narayan Temple
7. Pashupati Nath Temple

Like wise Lumbini also declared as world Heritage site in 1997 AD.

Different types of monuments used different organic as well as inorganic raw materials such as stones, bricks (terracotta), copper plate, brass plates, mud, tiles and wood. So these are being deteriorated by different factors like environment, Pollution, Biological, Mechanical and chemicals. Such monuments attract thousands and thousands of national and international tourist, which generate a lot of money. Not only this but also give information regarding the history of country and great person. Hence it is essential and important to preserve and conserve them. Here the author is interested to explain some preservation and chemical conservation work of Bhaktapur Durbar Square monuments because

this site is not only enlisted in world heritage site but also important in tourism aspect too.

2. Types of Monuments

There are different way of classification of monuments. As mentioned in the Ancient monument Act 2013 and 2048 (including amendments), monuments are categorized into three different groups from touristic point of view.

- i. International monument
- ii. National monument
- iii. Local monument

Some classified monument into two groups from use point of view,

- i. Living monument: Pashupati Nath, Changunarayan, Dachchinkali, & Swayambhu Nath Temples etc. come under the living monument because of daily use.
- ii. Dead monument: Dharahara, Ashoka Stupa at Patan, Shiva Temple at Hanuman Dhoka and some of the temples of Pashupati Nath come under the dead monuments, because they are not in daily use.

From the traditional architecture view temples are divided into following groups.

- i. Dome shape: Jung Hem Satya Narayan Mandir at Tripureswor.
- ii. Shikhara shape: Krishna Mandir at Patan
- iii Multi roof or
Multi tiered or
Nepalese traditional Pashupatinath, Changunarayan Mandir.

On considering the temples of Bhaktapur Durbar Square area there are:

Dome shape : Shiva Linga Mandir.

Shikhara shape: Rameshwor Mandir, Vatsala, Durga (Annapurna), Shiddhi Laxmi.

Traditional : Narayan, Krishna, Pashupati.

Beside these are other very interesting monuments such as 55 (fifty five) windows Durbar,

which was built in 1697 AD during Bhupatendra Malla period.

Swornadhoka or golden gate, which was gilded in 1754 AD during Ranjit Malla period (1722-69 AD_

There are lot of beautiful wood carving, tudals, toran, windows, doors, cornices etc., beside these many other materials are associated with the monuments such as stone, clay, terracotta, copper, bronze, silver and gold etc.

3. Deteriorating factors of monuments:

Deteriorating factors of monuments are basically based upon its surrounding environment, pollution, biological condition, chemical and so on. The condition of the monuments depend on use of them, also plays a vital role, which deteriorate the monuments. On considering few examples of Bhaktapur Durbar Square temples and other monuments give basic idea about problems of the monuments.

i. Vatsala Durga (Annapurna) and Shiddhi-laxmi.

Both of these are shikhara style, temples made of stone, usually sand stones type found around Kathmandu Valley, are used in these temples. The sand stones could easily be deteriorated, due to unfavorable condition of environment & pollution. Dust from different sources like automobile, dismantling houses and other could accumulated on its surface; wind and birds also carry different seeds of plant. During the monsoon season and thunder storms the acid rain can drops on stone surface & water porcolates from the stone joint and cracks portion. Some of the water soluble salt are deposited on the surface. It looks white in colour, may be some salt of Chloride/Sulphate/Carbonate. Due to deposition of such salt flaking of stone chips are also noted.

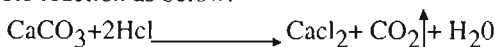
Under the favourable condition some of the cryptogamic groups of plants: Algae, Moss, Lichens,

and others are grown up on broken joint portion of stone. They die in dry weather and proliferate again forming humus. Taller plant or higher group of plants: Peepal, Bhimsenpati and other grown up, when some birds excreta with seed drops on this surface. under the favorable condition it grown up, after years and years it makes ugly look the temple, finally they damage the stone temples, such examples are seen over there.

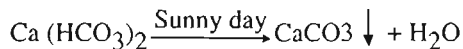
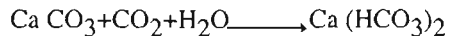
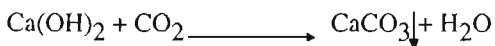
(II) Rameshwor Temple (Shiva).

This is Shikhara style terracotta temple. In this temple burnt brick (terracotta), wooden materials and clay binding materials (mortar+slaked lime) are used. This temple deteriorated by environment, pollution, biological and chemical factors. Dust and dirt from different sources accumulated on the surface of this temple, also some of the plant seeds, plenty of lower plants were seen on the surface. On winter season surface of such plant changed into black colour. Some of the lower plant like Lichen produce Lichenic acid, Liver worts plant produce humic acid, such acids damage and change the smooth surface of bricks and terracotta into rough and brittle. On the top of the temple (i.e. GAJUR) higher plant were also observed, turning the temple into ugly structure.

Around the middle portion of the temple at four sides East, West, North and South, there are beautiful decorative terracotta object of different varieties i.e. arts of god and goddess, such decorative terracotta objects were highly deteriorated by white colour salt formation. Such salt formation is caused due to the environment, pollution and chemical effect. There are different view of formation of white color solid salt, was identified as Calcium Carbonate or chalk, because of effervesence with Hydrochloric acid possible reaction as below:

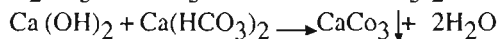
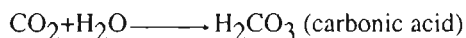


Formation of Calcium Carbonate in terracotta object:-



In newly made terracotta objects remain some Calcium Oxide, which on react with moisture changed into Calcium Hydroxide, when it reacts with atmospheric Carbondioxide form white solid materials i.e. Calcium Carbonate or chalk. On continuous reaction with atmospheric Carbondioxide on moist condition white solid materials disappeared, i.e. Calcium bicarbonate on sunny day again form which solid materials i.e. Calcium Carbonate as indicated above chemical reaction.

Mechanism of chemical reaction for the formation of calcium carbonate.



Here also atmospheric Carbondioxide reacts with atmospheric moisture under suitable condition form Carbonic acid, on reaction with Calcium Carbonate which form Calcium bicarbonate. Some time Calcium bicarbonate react with Calcium Hydroxide and form Calcium Carbonate and water. Such Calcium Carbonate appeared as white solid materials on the surface of the terracotta objects, it looks ugly and finally they are filled in the carving portion of the terracotta object.

There are some wood carvings (door, window, and plain plank) fitted in different parts of the temple. Such wooden objects are deteriorated by insects like termites, beetles. Effect of such biodeterioration mainly depends upon quality of wood and environmental condition of its surrounding. Soft wood are affected quickly by insect but same is difficult in hard wood. After the great earthquake of 1934 in Nepal, majority of woods were replaced by soft wood, so biodeterioration rate is higher in such case. Observation of anatomy of soft and hard wood

is clearly indicated that soft wood is quickly affected by insect rather than hard wood, because of many insect food materials like carbohydrate, starch and, some insect edible plant cells present in it. The durability of the some wooden species are

Illustrated below:

Extremely durable:

1. *Acacia catechu* (cutch)
2. *Mesua ferrea* (Iron wood).
3. *Tectona grandis* (teak)
4. *Xylia dolabriformis* (Jambu)
5. *Hard wickia binata* (Mar)

Very durable:

1. *Artocarpus lakoocha* (Dahu, Dhau)
2. *Cedrus deodara* (Dar).
3. *Cupressus torulosa* (cypress)
4. *Dalbergia lantifolia* (Indian Rose)
5. *Dalbergia sissoo* (Sissoo)
6. *Shorea robusta* (sal, Sakhu)

Durable:

1. *Acacia nilotica* (Black wood)
2. *Adina cardifolia* (Haldu)
3. *Albizia lebbeck* (Indian walnut)
4. *Syzygium cumini* (Jaman)
5. *Pinus walli chiana* (Salla)

Fairly durable

1. *Anogeissus lantifolia* (Elastic tree)
2. *Mangifera indica* (Mango tree)
3. *Quercus sp* (Oaks tree)
4. *Terminalia belerica* (Bahera)
5. *Terminalia Chebula* (Harara)

Slightly durable

1. *Butea monosperma* (Palas tree)
2. *Bombax Ceiba* (cotton tree)

Perisable

1. *Dalbergia paniculate* (Padri)
2. *Sapium insigne* (soap tree)
3. *Sterculia spp.* (Jangal Badam)

4. Preservation and Chemical Conservation

For the preservation of monument from the environment and pollution, His Majesty's Government of Nepal and Bhaktapur Municipality have jointly conducted the programme on control of automobile movement inside the Durbar square area". It helps to control the automobile pollution i.e. effect of various inorganic as well as organic gases (Nitric acid Sulphuric acid & Carbonmonoxide) etc. Beside these vibration movement on monuments is automatically controlled. His majesty's government of Nepal and the government of Federal Republic did a great job by preserving the whole city of Bhaktapur from dust, dirt and drainage pollution by laying burnt bricks on roads, courtyard and other empty spaces, not only this but also made proper water and sewerage system in different areas. It controlled the dust, dirt, biogasses and other gas pollutions, which creates adverse effects on the monument, it also gives good impression to the tourist.

The treatment for the eradication of cryptogamic plants: Algae, Moss and Lichens are also very important and essential. Firstly soak the such effected area with 2-3% dil. ammonia solution in both stone and terracotta, then gently brush with jute or hair brush depending upon the condition of the objects, wash out thoroughly with neutral liquid detergent, then cleaned surface kept dried at usual temperature, applied with 1-2% aqueous fungicidal solution. This treatment repeated after an interval of about a week. For the eradication of higher plants. Pipal, Bhimsenpati and other, it controlled in different ways:

i. Physical ii. Chemical

In physical method removed the plant completely from the monument. If the plants are not possible to remove completely use the chemical methods. In the chemicals method two different chemicals methods used:

- i. Blocking photosynthesis process.
- ii. Destroying the plant cell.

In first case spray herbicide like Glyphosate 40% S.L. (1:1) in water on whole plant, after one or two weeks all the photosynthesis process is arrested and the tree become black and green leaves changes into black colour. Similarly same chemical can be injected in plant body also. Beside this chemical there are other herbicides also available in market such as Paraquat, Diaquate, Dinoseb acetate, 2-40 (Disodium salt), Atrazine, Picloram, Dalapon, Dicamba. In second case plant body cut off down to root portion as far as possible, make hole using drilling machine, injected 1-3% aqueous Sodium Arsanate solution, preventive care should be taken while using these chemical, because of toxicity to human beings and other animals. After three or four applications of these chemicals, plant cut off surface sealed by some sealing agent Wax/Epoxy Resin.

The treatment of the wood, in the Rameshwor temple (Terracotta Shikhara) fitted wood carved doors, Dhalin (Beam), Nina (Lintel) Tham (wooden post), Sa (Along peg) and other. After the earth quake in 1934 AD (1990 BS) some of the wooden materials were replaced by soft wood i.e. Pine wood. Chemically it contain Resin, & Turpentine oil. It is durable also but not extremely and even very durable. Beside this wood Sal and Sakhu also used, it also contains chemicals like Formic acid but this wood in very durable. Both of these wood are made of organic compound, may be the food of insect as well as fungi. Due to this post insecticidal and fungicidal treatment is necessary. Following types of insecticides are available in market and also chemical laboratory of DOA.

1. Xylophene (French)
2. Wikamol (British)
3. Killgerm (British)
4. Xylamon (Japaness)

5. Dust band (Indian)
6. Aldrin 30% EC. (Indian)
7. Malathion (Indian)
8. Gammexane (Indian)
9. Asco (Indian)
10. Parathion (Indian)
11. DDT (Indian)
12. Chlorpyrifos 20% EC

Among these chemicals xylophene in kerosine, linseed oil (0.5:9:1) was applied in entire wooden object by brushing technique. Here kerosine oil carries insecticide and penetrates deeply into the wood, where as linseed oil polymerizes and shields the porous part of the wood, not only this but also it gives good resistance for insect and water.

The treatment of the metallic object (copper and brass) in Gajur and bell in the temples, due to formation different colour salt i.e.

Red and Brown	—Cu ₂ O cupreous oxide.
Green	—CuCO ₃ Cu (OH) ₂ Malachite
Blue	—2 CuCO ₃ Cu (OH) ₂ Azurite
Blue	—Cu ₂ O (CH ₃ COO) ₂ Basic copper acetate
Bluish Green	—Cucl cuprous chloride
Pale Green	—Cucl(OH) Basic cupric chloride
Green Colour	—CuSo ₄ 3cu (OH) ₂ Basic coppersulphate.

deteriorate the metallic object, these are cleaned one of the following chemical treatment

1. 5% sodium sesquicarbonate
2. 5-15% Sodium hexameta phosphate
3. Ethylene Diamine tetra acetate EDTA
4. 2-5% citric acid
5. Alkaline Rochelle salt.
6. Alkaline glycerol

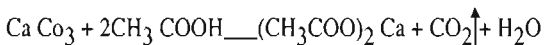
Here used number 4 and 6 chemicals after complete chemical treatment residue of these chemicals thoroughly washed out with neutral

detergent. Further control of Copper salt formation used 3% Benzol triazole in Methanol and 3% Poly vinyl Acetate in Sulphur free Toluene.

The treatment of terracotta objects and stone objects in the temples, crack portion or joint portion caused the leakage of water during rainy season, such portion are sealed by mortar mixing slaked lime and brick dust. Beside these there are other joining materials e.g.

- mixture of Rosine/jute/saw dust
- sand+ chalk dust
- Cement + sand + brick dust
- Slaked lime + Stone powder +black urad dal+ biocide + PVA
1.0:3.0 (6-10%) (1-2%) (10%)

White calcarious materials or calcium carbonate deposited on terracotta object removed or cleaned by using 5-10% aqueous Acetic acid solution using soft brush, knife and needle, the chemical reaction of this treatment as follows



Here calcium carbonate reacts with Acetic acid and form soluble salt of Calcium Acetate, Carbondioxide gas and water. Some of the Calcium Carbonate and Calcium Acetate may still be present in terracotta object, removed by mechanical method. After removing all the white solid materials, thoroughly wash out with neutral detergent to remove all the acid from terracotta object, leave them to dry at room temperature.

Different types of terracotta and stone preservatives are available in market i.e. Siliconate, syltrate, Monsonary, PVA, chemisol, and wax etc. Water resistance tested result of these chemical result shown as below, indicated that

Samples	Bank (drying time)	10% Sample (drying time)
Siliconate	0.08 hrs.	2.19 hrs.
Syltrate	0.08 hrs	2.54 hrs.

Monsonary	0.08 hrs	1.35 hrs.
P.V.A	0.08 hrs	2.14 hrs.
Chemisol	0.08 hrs	1.15 hrs.

with and without chemicals at 25⁰ C syltrate is better than PVA, siliconate, monsonary and chemisol. So syltrate compound is used in terracotta objects and 2-3% PVA is used in stone temples. It acts as consolidation for flake stone object. To make more water resistance or repellent Vaseline form of wax is coated on it with hair brush upto 1mm thickness. Firstly object looks dull, after 48 hours some of the wax melts and penetrates into porous part of stone, due to effect of heat from sun, wax acts as good consolidant as well as water proofing agent finally looks object very nice.

5. Conclusion

For the preservations of Nepalese Ancient monument, His Majesty's Government had given full responsibility to the Department of Archaeology (DOA), in 1952. Not only this but also passed the Act i.e. The prachin Smarak Samrakshan Ain 2013 (1956-1957). Beside this UNESCO and World Heritage committee listed some Nepalese monuments on considering the Kathmandu, Patan and Bhaktapur Drubar square, there are full of different categories of monuments: shikhara temples, traditional Nepalese style, Dome style, Big bell, statue of late kings and rest houses. The temples and monuments generally deteriorated by Environment, Pollution, Biological, Chemical and mechanical factors, are now in controlled condition. Within Kathmandu Durbar Square roads and open space are laid with squares flagstones, where as Patan and Bhaktapur Durbar squares are covered or laid with burnt bricks. Vehicular movement are strictly controlled which made the area free from the dust, dirt and gas pollution. Beside these, Government has managed properly water and sewerage system to control the effect of inorganic and biogas pollution in the monument. It also gives



Terracotta before cleaning
(Deteriorated by white calcarious material deposition)



Terracotta after cleaning

excellent impression to tourist. For technology development on chemical conservation of monument His Majesty's Government of Nepal has established chemical conservation laboratory in 1972 and provided all the necessary requirements like chemicals, tools and technical assistant from UNESCO. The staffs are also trained inside the country as well as in abroad. For the eradication of plant, pre and post herbicide treatment is recommended, the author further suggested that to use suitable soil i.e. Dark yellow soil (Mahshucha), mixing with some herbicide (Karmex in alcohol), while using tile in multi roof temples and brick work. White salt formation on terracotta object should be clean with organic acid rather than inorganic acid, preservative coatings either on stone or terracotta should be done after testing. Water soluble syltrate and wax Vaseline in terracotta and stone object has shown the excellent result. To controlled the insect deterioration the author suggested to use hard wood rather than soft wood, because of various biodeterioration problems. Some of the insecticides and its application technology are recommended which are available in market and chemical laboratory. Herbicidal, Insecticidal and other chemical treatment should be done under well protected condition and in presence of trained chemist, because of strong toxicity to human being. Finally to prolong the life of the monuments "Preservation is better than cure" principle should be followed up.

6. References:

1. Agrawal, O.P., Mishra, Jain "Removal of plants, trees from historic building" INTACH< Lucknow; (1994).
2. Agrawal, O.P. "Termites A major Problem in Museum", International centre for conservation Rome (1979).
3. Agrawal, O.P. "Care and Preservation of museum objects"

4. Archaeology Dept. "Prachin Smark Samrakshan Ain 2013/2048."
5. Banerjee, N.R., "Nepalese Architecture" Agam Kala Prakashan, Delhi (1980).
6. Benthall, A.P. "The trees of Calcutta" Thacker spink & Co. (1933) London.
7. Bhandari, Bishnu, "Inventory of Heritage site of Nepal" IUCN the world conservation union (1997).
8. J.C. Wills, "A Dictionary of the flowering plant and fruits" R.P.S. Gahlot Dehra Dun (1982).
9. Korn, Wolfgang "The traditional Architecture of the Kathmandu Valley" Ratna Pustak Bhandar, Nepal (1976).
10. Mehta, Tribhawan; "A Hand book of forest of Utilization" Pub. Perivdical expert book agency Delhi" (1981).
11. Plenderleith, J.H. and werner "The conservation of Antiquites and work of arts" London Oxford University Press New York, Toronto" (1971).
12. Singh G.M. "Conservation of copper plate inscription" Abhilekha" PP. 132-139 Vol. 15 (2054).
13. UNESCO "The conservation of cultural property" Rome Italy (1968)
14. भक्तपुर "पासुका" नेवारको निर्माण प्रविधि जोडने सामाग्रीहरू अङ्क ९ वर्ष १ पेज ६ जेष्ठ (२०५४)