



# Deterioration Processes of Historical Monuments

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**ABSTRACT:** The problem of the conservation of historical monuments (statues, columns, ancient buildings) requires a careful study of the many environmental agents that determine it the impairment process and affect the actual impairment rate. Among the supreme active causes of atmospheric agents, we can mention: (1) the weakening of the outer layer of the work of art, which is caused by complex microphysical effects and is due in specific to wetting of the external part layer of the artwork (a comparison between the effects of rainwater and condensation is done); (2) the chemical-physical act of the pollutants captured in both the dry and wet stages. Most research studies reveal that the effect of acid deposition on modern structure is significantly less than the result on ancient monuments. The historical structure of the entire world is affected by pollution, air, noise, and water pollution. The main atmospheric degradation processes are due to the combined action of rainwater and atmospheric pollutants (in particular carbonaceous particles due to combustion) deposited on the surface of the monument. The marble in the Taj Mahal was observed to be discoloring and taking on a yellow appearance. It was feared that the discoloration was due to air pollution.

**KEYWORDS:** Pollution, monument, Environmental composition, pollutants

## I. INTRODUCTION

### Acid rain:

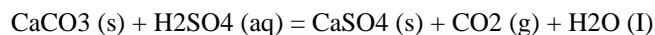
The rate of deterioration of monuments occurred with the general increase in industrialization and urbanization, especially after World War II, many authors have suggested that this phenomenon could be attributed to the increasing rate of air pollution and, in particular, with sulfur dioxide. In this hypothesis, the degradation process is mainly due to surface action sulfur pollutants removed from the atmosphere through condensation processes. The corrosion of marble and limestone would be due to the transformation of the sulfur compounds, in particular sulfur dioxide in the presence of catalysts in sulfuric acid on the surface of monuments. Acid rain has been identified as another possible cause of stone deterioration. Many studies have been conducted in this direction with conflicting results. If we look at a monument, we can see it, the parts most exposed to damage caused by rain, that is, those that suffer runoff, have deteriorated in different ways so protected from runoff. The proposed aging process has, in practice, three stages: (i) atmospheric gases dissolved in water chemically form active solution; (ii) it reacts with the stone and forms the crust, transforming a part of it the calcite from the plaster statue, more soluble in water; (iii) the following the rain washes the scab removing a layer of stone. The loss of material It is a function of both the pH, considered as an index of the aggressiveness of rainwater, and the intensity of the rain that provides a new unsaturated solution in contact with the surface of the monument. The process would be more active if the precipitation occurred on the already wet stone.



Figure 1: Deterioration of Monuments

Actually, areas subject to runoff are thinned out in marble monuments. Considering the passage indicated above, sulfation is hardly present. When outflow is prevented, sulfation is at its greatest. Therefore, you must conclude that: (i) a significant part of the sulfur compounds deposited by dry acid rains are not enough to affect the stone are deposition processes and the air; (ii) the main action of is to thin the stone, but only acid rain to explain the formation of one of the worst types of stone deterioration: the formation of well-known black crusts, essentially composed of gypsum crystals and soot particles. The role of chemicals has been extensively studied since the first issue. However, many problems remain unsolved. It could be assumed that both Sulfur dioxide and acid rain are partially responsible for the deterioration of the stone, but to what extent is not easy to say.

Acid rain can damage buildings, historical monuments, and statues, especially those made of rocks, such as limestone and marble, that contain large amounts of calcium carbonate. Acids in rain react with calcium compounds in stones to create gypsum, which then breaks down.



The effects of this are commonly seen on old tombstones, where acid rain can render the inscriptions completely illegible. Acid rain also increases the rate of corrosion of metals, particularly iron, steel, copper, and bronze.

In India, limestone is one of the main stones used in the construction of various monuments and states, including the Taj Mahal.

Places significantly affected by acid rain around the world include most of Eastern Europe from northern Scandinavian Poland, the eastern third of the United States, and southeastern Canada. Other affected areas include the southeast coast of China and Taiwan.

## II. MICROCLIMATIC FACTORS

Solar radiation causes the exchange of heat and humidity between the atmosphere and Monument. The fluxes of heat and humidity can favor or counteract the processes of deposition of atmospheric pollutants and gas adsorption. In any case, the deposition rate is a function of not only the concentration of contaminants in the atmosphere, but also of different deposition processes, which are themselves a function of both atmospheric and surface characteristics. Furthermore, these

processes are generally unknown. This explains how difficult it can be to establish a correlation between the concentration of air pollutants and damage to the stone that will be produced. The diurnal thermal cycle of the monument associated with the variation of specific ambient humidity, can cause condensation-evaporation cycles in the surface of the stone, which in turn depends on the temperature, presence and type of stone-soluble salts and the dew point of the ambient air. This is clearly not correct. Consider only the relative humidity of the surrounding atmosphere to make a model of this process. Evaporation caused by the wind carrying unsaturated air masses can have a different effect from the evaporation caused by solar energy that heats the monument. The wind plays a very important role in increasing the evaporation rate, i.e. associated with transport through the stone of liquid water containing dissolved salts and recrystallization where evaporation occurred. The wind-caused evaporation typically occurs on the surface of damp walls and is therefore effective in transport of salts to the surface and formation of efflorescence.

Solar radiation provides energy to the stone favoring its evaporation in surface and in the pores of the subsoil and deeper layers. Rain is one of the most important meteorological agents, especially when it is associated with the wind. Protruding parts of monuments (such as an arm) and lower parts of some buildings are less exposed due to deflection of the transported wind field drops falling. Apart from the transport of heat and impulse, precipitation is responsible for supplying large quantities of liquid water, which cannot be supplied by condensation medium. The amount of water supplied by precipitation causes runoff or it can only wet the surface, depending on the speed and direction of the local wind topography, exposure and geometry of the surface. Water supply, when associated with aggressive chemical agents, can cause chemical reactions and dissolution of the stone.

Deterioration processes are favored when wetting / evaporation cycles are more frequent. In general, condensation (both external and internal) is expected to play a role in deterioration processes, because: (1) it is suspected of providing the necessary water for both chemical reactions between stone and dry deposition and for deposition. dissolution of the original stone; (2) induces pheric forces; and (3) increases the efficiency of collection of vertical surfaces regardless of the deposition process (Brownian, thermophoretic, diffusiphoretic or aerodynamic impact). Evaporation on the other hand: (1) concentrates the solution; (2) favors internal recrystallization and efflorescence; and (3) induces stresses in the stone and increases the pressure of the water vapor trapped within the stone. More frequent condensation / evaporation cycles are not required in the dead of winter, when pores tend to be filled with water.

Ice crystallization, often referred to as an "ice wedge" or "ice wedge," could be a variety of physical erosion that typically occurs in cold climates. Ice crystallization occurs when water penetrates into a crack or hole within the surface of a monument, then freezes, as the water expands once it freezes, widening the crack within the monument and could eventually crack and break objects, shaping the monument and requiring costly restorations and repairs.

### III. PREVENTION

To protect monuments from deterioration it is necessary to take the necessary precautions. It should be done by reducing the occurrence of splashing during rain by replacing water collection and drainage systems (eg open drain) that increase splashing or soaking. Protect the jambs from drops of water, dropped directly or in flight, using a discreet glass plate, placed at a short distance (~5cm) to allow free exchange with the atmosphere and avoid the greenhouse effect. This would also reduce the heat loss from the stone and protect it from mist-induced damage, both caused by the impact of the drops on the stone. Eliminate all possible forms of water infiltration inside the stone; in particular, seal all scaffold support holes and external cracks without altering the appearance of the building. Waterproof the wall, at least partially, without however altering its vapor permeability. Install suitable devices to discourage pigeons and other birds in order to avoid the introduction of substances that favor the deterioration of the masonry. Traffic control must be well managed around the monument so that vehicle horns do not generate sound waves, which exert pressure and generate vibrations on the surfaces of the particles that cause the cracked and eroded surface of the monument and historical building. . Hardwood plantations along the road and around the city's industries that trap dust, smoke, consume CO<sub>2</sub> gas because this CO<sub>2</sub> does not turn into weak carbonic acid in contact with water around the monument of vehicles and industries.

### IV. CONCLUSIONS

In general, spoilage is quite complex and involves both chemical meteorological compounds and variables, and sometimes a biological attack. IT IS impossible to determine general formulas involving contamination levels, massive deposition and damage, valid for all microclimatic conditions. The reason is that microclimate levels and gradients are not just boundary



conditions, but independent variables that can trigger different processes and must be studied from this point of view. The different forms of damage seen in marble and limestone depend on the way the rain wets the monument: from one end, a complete washing of the surface (white areas), to the other where the surface is wet and the dry deposit is not removed but activated (black areas).

This is clear evidence that dry spawning per se may not be a sufficient condition for deterioration of exposed stones, unless not supplied in sufficient quantity to trigger degradation processes. With respect Condensation plays less of a role than rain.

The deterioration of the monuments depends on the aggressiveness of the solution that they will form when they get wet. Especially in urban areas where the stool is dry dominates, the pH of the precipitation may be of secondary importance for contribution of dry deposition. And, in this article, we can say that the increase in the level of contamination is the main cause of deterioration. Too much industrial activity and no control over the pollution they cause are reducing the life of monuments day after day. All of this can be controlled by adopting the appropriate guidelines provided by the environmental pollution control agency of the respective country. All of these measures will help to protect historic monuments for the future.

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