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ijirset@gmail.com



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A Case Study on Detrimental Effect of Air Pollution, Corrosion on Building Materials & Historic Structures

Vishal Kumar Meena¹, Abhishek Mahawar², Deepak Meena³, Dr.Kuldeep Singh Kulhar⁴,
Javed Ul Islam⁵

B.Tech Student, Department of Civil Engineering, Vivekananda Institute of Technology, Rajasthan, India¹⁻³

Associate Professor, Department of Civil Engineering, Vivekananda Institute of Technology, Rajasthan, India⁴

Assistant Professor, Department of Civil Engineering, Vivekananda Institute of Technology, Rajasthan, India⁵

ABSTRACT: The economy of any country would be drastically changed if there were no corrosion. The annual cost of corrosion world wise is over 3 % of the world's GDP. As per the sources available, India losses \$ 45 billion every year on account of corrosion of infrastructure, Industrial machinery and other historical heritage. Air pollution results from human activities such as burning fossil fuels (oil, coal, and gasoline) to create electricity and power automobiles, and manufacture industrial products such as chemicals and plastic. • The air Pollutants are particulates, HC, CO₂, CO, NO, NO₂, SO₃ -- source may be industrial, autos, etc. World Wonder Taj Mahal is Turning Brown Due to Air Pollution • Effects of Air Pollution on Materials, Including Historic and Cultural Heritage Monuments.

KEYWORDS: Air pollution, Corrosion, Historical monuments, Electrochemical corrosion, Oxidation.

I. INTRODUCTION

It refers to the condition in which the existence of toxic substances in the atmosphere, generated by various human activities and natural phenomena such as volcanic eruptions, results in damaging effects on the welfare of human beings and the living environment" (Omasa 2002). The impact of air contamination on materials might be found as far as staining, material misfortune, primary fizzling and ruining. Both staining and underlying disappointment because of air contamination on structures might be immaterial and that may not include tremendous costs. The potential for damage to historical monuments has already been realized. Some damage, such as from wind or rain, is unavoidable. However, pollution contributes additional risk factors that can increase the level of destruction. The effects may be minor, such as a blackening of the surface of monuments due to dust.

❖ *Materials Affected*

Indeed, all most all materials are influenced by the testimony of corrosive, yet the level of harm or power might be differed. Some of them are more helpless to the influence such as Carbon, Steel, Zinc, Nickel, Limestone, Marble, Paints and a few plastics. Fundamentally metallic materials are ruined because of erosion. Oxygen what's more, dampness are the main specialists answerable for consumption. Lowered designs like establishments and lines will likewise be influenced by fermented waters because of erosion brought about by corrosive assault.

❖ *The Chemistry of Corrosion*

The most notorious pollutant responsible for metallic corrosion is sulphur dioxide, it has been reported that corrosion of hard metals such as steel begins at annual mean concentrations of 0.02 ppm. When the pollutants fall on to the surface of the material the intensity of reaction depends on the nature of the material and amount of moisture content present in when SO₂ falls as dry deposition on the material, it is oxidized to sulphuric acid in the presence of moisture in the surface. Acid Rain. One of the more destructive forms of pollution is acid rain. When acid rain falls on historical

monuments of limestone or marble, a chemical reaction takes place which has a corrosive effect on these structures. The reaction dissolves the material, leading to permanent damage.

❖ *Effect of Air Pollution On Materials*

The damage thanks to pollution on materials is de facto a heavy concern since the service lifetime of buildings is remarkably reduced. It's true that the intensity of manmade pollutants on building degradation is over the impact of natural pollutants. Most significantly the effects of soiling, degradation, corrosion and erosion caused by SO_2 are much serious. The effect of pollution on materials could also be seen in terms of discoloration, material loss, structural failing and soiling. Both discoloration and structural failure because of pollution on buildings is also inconsequential which might not involve huge costs. But the effect of corrosion thanks to acidic deposition costs lots. Especially the effect of gas and gas emissions is extremely much significant. The effect of salt has been very significant and should be continued for fairly while. When carbonate dissolves in oil of vitriol ends up in the formation of calcium sulphate. The calcium sulphate when it falls on stone breaks the surface of the building blocks.

II. RESULTS & DISCUSSION

A. *Major Air Pollutants – Effect*

Air pollutants deteriorate by five ways such as abrasion, deposition and removal, direct chemical attack, indirect chemical attack and corrosion. Air pollution is directly responsible for economic losses in urban areas. The atmospheric deterioration of materials are caused due to moisture, temperature, sunlight, air movement and the position of the materials.

Table: 1 Effect of Air Pollution on Materials

MATERIAL EFFECTED	RANGE OF SENSITIVITY
Brick	very low
Concrete	low
Mortar	moderate to high
sandstone, limestone, marble	high
Unalloyed steel	high
Stainless steel	very low
Nickel and nickel-plated steel	high
Zinc and galvanised steel	high
Aluminium	very low
Copper	low

C. *Oxides of Nitrogen*

Nitrogen oxides are produced in combustion processes, partly from nitrogen compounds in the fuel, but mostly by direct combination of atmospheric oxygen and nitrogen in flames. Nitrogen oxides are produced naturally by lightning, and also, to a small extent, by microbial processes in soils.

Table: 2 NO_2 Levels in Indian Cities

CITY	RANGE OF AVG. CONC. (PPM)	RANGE OF MAX. CONC. (PPM)
Mumbai	0.008-0.13	0.013-0.05
Delhi	0.008-0.13	0.016-0.035
Kolkata	0.006-0.17	0.023-0.051
Kanpur	0.01-0.095	0.02-0.013

D. *Oxides of Sulphur*

It is a corrosive gas comes from chemical, paper industries when it reacts with atmosphere it causes acid rain. The most notorious pollutant responsible for metallic corrosion is sulphur dioxide, it has been reported that corrosion of hard metals such as steel begins at annual mean concentrations of 0.02 ppm. Sulphuric acid mist in the atmosphere causes

deterioration of structural materials such as marble sculptures and buildings have suffered damage in the last 30 years as a result of increased SO₂ content in the atmosphere.

Table: 3 SO₂ Levels in Indian Cities

City	SO ₂ Level (µg/M ³)
Mumbai	47
Kolkata	33
Delhi	41
Chennai	08
Hyderabad	05
Kanpur	16
Ahmedabad	11

E. Carbon Monoxide

The combustion of fossil fuels ends up in the emission of a range of pollutants in to the atmosphere of which the key ones are Sox, NO_x and CO. Particularly the most sources of CO within the urban air are smoke and gas of the many devices, burning coal, gas or oil. These point sources show an enormous impact on the structures exclusively located near by the factories from where they're emitted.

Table: 4 CO Levels in Urban Cities

City	Max. 1 hour CO (ppm)
London	58
Chicago	46
Los Angeles	43
New York	27
Kolkata	35

F. Particulate Matter

Particulates such as soot, dust and fumes soil painted surfaces, fabrics and buildings, and because of their abrasive nature, particulates can cause damage to exposed surfaces when they are driven by wind at high velocities. Through their own corrosiveness or in the presence of SO₂ and moisture, they can accelerate the corrosion of steel, copper, zinc and other metals.

Table: 5 Particulate Matter Levels in Cities

City	Particulate level (µg/m ³)
Mumbai	240
Kolkata	340
Delhi	601
Chennai	100
Hyderabad	146
Kanpur	543
Ahmedabad	306

G. Indian Ambient Air Quality Standards

The Central Pollution Control Board in India has set up ambient air quality standards with regard to permissible concentration of the following pollutants:

Table: 6 Indian Ambient Air Quality Standards

POLLUTANT	INDUSTRIAL AREA ($\mu\text{G}/\text{M}^3$)	RESIDENTIAL AREA ($\mu\text{G}/\text{M}^3$)	SENSITIVE AREA ($\mu\text{G}/\text{M}^3$)
Sulphur dioxide			
Annual Avg.	80	60	15
24 hrs	120	80	30
Oxides of Nitrogen as NO_2			
Annual Avg.	80	60	15
24 hrs	120	80	30
Suspended Particulate Matter (SPM)			
Annual Avg.	360	140	70
24 hrs	500	200	100
Carbon Monoxide			
8 hrs	5000	2000	1000
1 hr	10000	4000	2000

H. Intensity of Damage

A large portion of the exploration considers uncovered the impact of corrosive testimony on current constructions is essentially not exactly the impact on antiquated landmarks. All most all legacy structures are developed with limestone and calcareous stones which are generally powerless against erosion. Thus nonstop remodel and retrofitting is an unquestionable requirement to ensure our legacy. The notable designs from one side of the planet to the other are influenced by corrosive downpour. The vast majority of the examinations for the lengthy timespan zeroed in on the impact of sulphur contaminations, later the interest was redirected with the impact of nitrogen build-ups on the constructions. A significant number of the specialists did concentrates on sulphur and nitrogen contaminations independently, they discovered their force of harm on materials. In any case, in the new past they could recognize the impact of ozone and its acidifying air contaminations: truth be told the impact of corrosive statement on material can be concentrates under two significant heads. The Taj Mahal, one of the Seven Wonders of the World, and India's pride, most prominent land mark is moreover being compromised from air and water contamination. The report presented by National Environment Engineering Exploration Institute intentionally shows that the seventeenth century landmark is being harmed via air and water contamination. This is being happened even after the healing measures taken by the public authority. The Ministry of Environment, Administration of India has directed an overview to discover current realities of contamination on the authentic burial place. The report has uncovered that the contamination levels as far as both air and water had rose to generally huge and riskylevel ,because of progressive development in industry, traffic and populace. Unlawful and silly developments are jumping up around the Taj Mahal, the vigorously contaminated water of the waterway Yamuna additionally causing a genuine harm to the landmark. An air contamination control program was dispatched in 1998 when it was discovered the landmarks acclaimed and impossible to miss white marble supposedly was becoming yellow. The then president Bill Clinton made an fascinating explanation that contamination had done "what 350 years of wars, attacks and cataclysmic events have fizzled to do and started to deface the superb dividers of the Taj Mahal". A progression of genuine forbidding measures have been taken including trying not to run of vehicles 500 meters from the design and refined gadgets are organized to give running check of air contamination. It was likewise seen that the variances in ground water table have been undermining the construction, the water in the waterway Yamuna is persistently dirtied by the release of effluents. Numerous specialists pronounced that the quantifiable Total Particulate Suspended Matter (TSPM), Respirable Suspended Particulate Matter (RSPM) and Oxides of sulphur and nitrogen are altogether presenting enormous dangers to the old amazing designs. The darkening of surface of designs because of the arrangement of residue layer over a timeframe. As per Suryanarayana Murthy, a preservation planner, the natural matter that choose the structure alongside the residue prompts moth development because of down payment and Pollution turning Taj Mahal yellow.

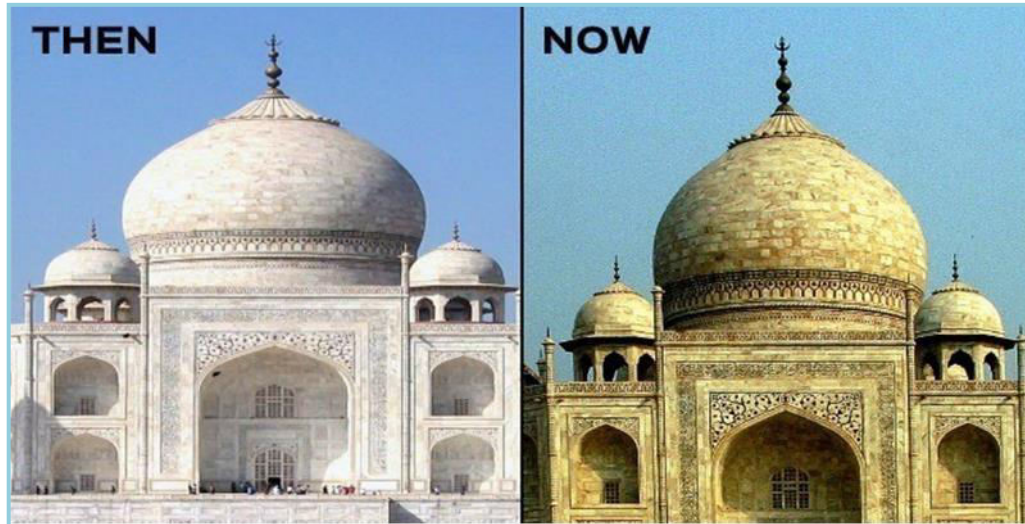


FIGURE 1: Pollution Turning Taj Mahal Yellow

Charminar, one of the greatest monuments in India, is being threatened by air pollution. Charminar was in most polluted area the TSPM recorded in 2010 was 267.5 and in 2012 it was 287. Some of the other oldest structures like Jama Masjid, Mecca Masjid and Badshahi Ashoorkhana are all affected by dust particulates. It was also identified by Murthy that the formation of the layer happens much faster on structures with a rough surface as in the case of Mecca Masjid, contrasted with the design with smooth and put surface like Charminar. It has likewise been distinguished that it might take around eight to year for a layer of 1 mm to shape over the outside of Charminar, in any case, it happens quicker on structures like Mecca Masjid where the tough stone is uncovered. Charminar is the most acclaimed symbol of Hyderabad, presently it has been experiencing lethal impact of air contamination. It was distinguished that the minarets of the landmarks have created air breaks at certain spots. Greenery and Lichen development has been distinguished on the dividers confronting the mosque on the subsequent floor and it was additionally seen on the means prompting the upper segments. It was chosen by Archaeological Survey of India (ASI) to take up fix exercises at an expense of Rs 10 needs. Truth be told ASI is approved to take care of its upkeep and it was additionally intended to take up substance wash of Charminar. As indicated by the accessible sources it was accepted that the air breaks shaped may be the aftereffect of climatic change. The substantial downpours that lashed the city as of late were accepted to frame hastened matters on the surface of the design. The leakage of downpour water and the moistness affect air breaks. Dr. Das, the Official of ASI said during 2001, one of the minarets had endured harm, however ASI had started a quick activity and redressed the issue.



FIGURE 2: Air cracks on Charminar



FIGURE 3: Pollution on Statue of Liberty

III. CONCLUSION

The present contribution showed a general description on the current state of some of the historical structures. As far as the pollution on materials is concerned the tropical climate with the presence of natural pollutants create conditions for deterioration of both metals and rocky materials. In fact the present situation of historical structures is at critical junction. It is necessary that the appropriate governments should initiate substantial measures to control the damage of structures. The awareness among the public is also important to stimulate the concerned authorities to initiate control and remedial measures. This paper tries to place the facts and bring awareness among the public and custodian authorities.

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