

***Environmental pollution, a threat to the
archaeological sites, heritage and tourism in
Zarqa, Jordan***

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Abstract

It is clear from the results of this study that the archaeological and heritage sites located within the Zarqa Governorate are exposed to the risks of industrial pollution that threatens the existence of this historical evidence, with the increasing size of the expansion of factories and workshops and residential complexes, the rate of increase of pollution on the rise, that we must take preventive measures to halt the deterioration in the foundations of these buildings and then implement a plan to mitigate damage caused by industrial pollution. All of the following are some suggested actions to find a solution to the problem of industrial pollution threat to cultural heritage. Available data indicate that air pollution in urban environments is mainly due to traffic. Since diesel vehicles greatly contribute to smoke and blackening of monuments, these should be replaced by electric vehicles in city centers or converted to alternative fuels. In addition, proposals for new air quality standards could require power plants, factories, car manufacturers and other major polluting industries to install cleaner technologies.

Keywords: Environmental pollution, cultural Heritage, Archaeological sites, Deterioration, Salts, Biodeterioration,

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التلوث الجوى: خطر على المواقع الأثرية فى مدينة الزرقاء - الأردن

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ملخص

الدراسة الحالية دلت على الأثر الواضح للتلوث الجوى على المواقع الأثرية فى منطقة الزرقاء فى الأردن المدنية تحت تهديد مباشر من التلوث الجوى مع الازدياد. المباشر للمصانع الصناعية فى هذه المنطقة. الدراسة دلت على أن معدل التلوث بازدياد متصاعد فى هذه المنطقة . مجموعة من الإجراءات الوقائية ضرورية جدا لوقف تدهور المواقع والمباني الأثرية فى هذه المنطقة من التلوث الجوى. الدراسة تقدم مجموعة من الاقتراحات لتقليل الاضرار الناجمة من التلوث الصناعى فى هذه المنطقة الغنية بالمواقع الأثرية.

نتائج البحث تشير إلى أن التلوث فى المناطق السكانية يعود إلى الازدحام المرورى وخاصة التى تعمل باديئل والتي تشكل خطراً مباشراً على المباني الأثرية. هذه الآليات يجب استبدالها بالآليات أقل ضرراً وخاصة حول المواقع الأثرية الهامة. قدمت الدراسة أيضاً اقتراحات خاصة لمراقبة التلوث والتقليل منه فى محطات توليد الطاقة والمصانع ومصادر التلوث الرئيسية فى المدينة

Introduction

Pollution has become a major issue over the years. It has caused death, disease, and many health problems. It is a major concern of our world today and not much is being done to prevent it. If not all, a lot of pollution is caused by humans. There are different types like industrial, agricultural, etc. Many people are realizing now the threat that pollution poses to humans. In our natural environment pollution is the single biggest threat to our current way of life. There are a number of variable sources of environment pollution, including air pollution, water pollution, ground water pollution, and land pollution. Of course noise pollution is another growing source of problematic pollution in our world as well. Every aspect of pollutants carries a very serious consequence in our daily and worldly environment. The most dangerous type of pollution is industrial pollution.

Zarqa is home to many industries, specifically in the sectors of power, oil refinery, chemicals, fertilizers, machine tools and pharmaceuticals. The environmental problems that arise due industrial activities are water pollution, air pollution, generation of hazardous waste and noise pollution. The by-products of these operations (particulates, the oxides of carbon, nitrogen and sulphur) have been emitted to the atmosphere in enormous quantities (Reida and John, 1988). This in turn negatively affects all aspects of life. This research will focus on industrial pollution, which affects not only our life but archaeological sites and monuments. Cultural heritage now plays an important role in sustainable development, with a direct impact on the national economy, where tourism contributes at a rate ranging between 15-20% of national income, which need more attention to relevant sites and development, by improving the performance of their services for the better in order to attract more visitors to the Kingdom, which will no doubt contribute in improving job opportunities and employment and in the development of the national product for the better. This in turn, places a requirement upon those involved in heritage conservation to seek further improvements to technological tools and to ensure a sustainability of approach. It is appropriate therefore to consider some of the main societal, environmental and economic pressures which face the cultural heritage. We now recognize a far wider range of cultural heritage materials than were

previously acknowledged, and these materials show just as much danger of being adversely affected by change as historic monuments and archaeological sites.

In Zarqa province Cultural heritage is subject to numerous pressures: man-made and natural; some can be prevented, others are unavoidable. Natural disasters, such as earthquakes cannot be prevented. The potentially catastrophic effect of natural disasters on cultural property can only be forecast through risk management exercises, and steps taken to minimize or at least manage any damaging effects. (Roletson, 1982). Nonetheless, virtually all the cultural heritage must be considered totally vulnerable to severe natural disaster and to phenomena associated with climate change.

Pressures on Cultural Heritage

Equally, the fabric of modern living often has serious, indirect effects on the conservation of cultural heritage. The following examples are highlighted in order to emphasize the inter-relationships between cultural heritage and their context.

- Agriculture and soils have major implications for the long-term preservation of cultural heritage. Cultural heritage research needs to consider the direct effects of soils strategies on the chemistry and biology of buried soils and on the physical structure of buried archaeological deposits.

- Water abstraction has a considerable and long-term influence on the ground water table, with effects on archaeological and architectural heritage. Aquifer levels are commonly monitored by construction industry watchdogs in different urban centers. However, this commonly relates to predicting potential damage to modern constructions such as building foundations and tunnels. And yet the implications of rising groundwater are just as serious for superficial deposits - and the archaeological sites and historic buildings within them. Although short-term effect is often taken into account, long term effect on the built heritage and on the (hidden) archaeological heritage is rarely considered. Monitoring of structural behavior of heritage buildings, their infrastructure and

the impact on underground heritage is not systematically carried out. Similarly, the potential groundwater implications of one development on adjacent sites are seldom considered. Water abstraction licenses are granted according to environmental need but without reference to the deleterious effect on cultural heritage of groundwater change.

- More generally, modern construction resulting from urban regeneration and other sustainable development initiatives can be at odds with our stated desire to protect and conserve the cultural heritage
- Construction impacts on above ground cultural heritage (standing 'monuments') are often easier to model than the very complex physical, chemical and biological variables in any buried archaeological site(Kennedy, D, 1981).This does not detract from the importance of guarding against unsympathetic development in the vicinity of an historic building, but it does highlight a more fundamental need.
- Finally, neglect is perhaps the most insidious threat, whether by deliberate intent, lack of awareness or concern, or lack of the necessary resources. Neglect is not only the failure to undertake necessary work on cultural buildings and objects; it can also consist of failure to develop appropriate legislation, the failure to observe incompatibilities between different statutory measures or policies, or the failure to undertake necessary research into preventive and remedial measures.

Pollution Effects: Monuments and Sites

Industrial pollution is a pest of the age and imminent danger threatens everything on earth. The industrial waste, water pollution, the use of chemicals in various spheres of life led a significant changes not only our lives but for the generations to come.

-Air pollution: although SO₂ concentrations have increased in recent decades, levels of smoke and particles are still high, and continue to damage urban monuments. In addition, data indicate that cars and other vehicles greatly contribute to the deterioration of monuments. Thus

steps should be taken to reduce concentrations of SO₂, and smoke and particles in particular, in Zarqa in general and specifically in the proximity of monuments. In addition, given current levels of urban traffic and smoke production, continuous maintenance and preventive conservation is required to conserve monuments and minimize damage. Available data indicate that air pollution in urban environments is mainly due to traffic. Since diesel vehicles greatly contribute to smoke and blackening of monuments, covering the surface layer of stones and lead to isolation, making it easier and helps to distort the upper layers and change their color, (Ashurst and Dimus 2001).

The industrial dust contains lead compounds and asbestos, manganese, beryllium, arsenic, copper and zinc, depending on the quality of industrial facilities that cause dust and as motor fuel (gasoline) contains a 3 to 4 cm³ of lead per gallon. So Zarqa Governorate climate is constantly affected by dust and dirt the buildings and archaeological sites are in continues subject to this kind of influence that leads to change the color of masonry and the distortion. Example the dust from the white cement factory and its impact on archaeological sites scattered around the factory (Shaheen, 1975, Ghazawi,1991).

The engines of vehicles generate toxic gases such as carbon dioxide (CO) and nitric oxide (NO), which reacts with oxygen on air to produce nitrogen dioxide (CO₂). As well as the resulting gas (SO₂) which reacts with water and form sulfuric acid (H₂SO₄) and this leads to the erosion of the stones by the interaction with them, and falling all the toxic gases in the form of acidic rain on the ground, where they accumulate in the soil over plants.(Torraco,2000),(Fielden,1994). The plain nature of Zarqa city and its surroundings, with low public awareness and lack of adequate maintenance of vehicles led to increase the accumulation of gas and particles over buildings and monuments. In general, polluted air which contains sulfur gases affects these building and monuments stones by disintegrating and damaging it. where they (Sulphu Gases) dissolved in rain water and interact with calcium carbonate t o produce calcium sulfate in the surface of the stone and turn this into sulphate crystals (Crystals)

when dry, since the crystallization process leading to increase the size they are working on cracking the stone from around the molecules near the outer surface, and as the calcium sulfate does not dissolve easily in water, it accumulates in layers, especially in the case of non-covered rocks exposed to continual rain, and when the crack on the surface of sulphate rocks fall they take a part of the components of the stone itself and of dissolved salts leaks into the pores of the stone, where the change of the size or the impact of exposure to drought, leads to the disintegration of parts of the stones slowly, and acts as frost on Freeze water in the pores of the stone and lead to increase the size of water molecules and then the disintegration of particles of stones, we can deduce from the above that the extent of damage resulting from the recent conditions (car exhaust) depends on the porosity of rocks in general, and the proportion of micro-pores (Fine pores) in particular, it is clear that the high proportion of pores lead to increase the size of the damage significantly, (Stambolov and De Bor, 1976).

The color of the stone is also affected by smoke exhaust of vehicles, which converts to a dark color. The knowledge of the characteristics construction stones contribute in the selection of the appropriate type to suit the prevailing conditions of different environments and can then avoid the use of stones, which affected by smoke exhaust fumes in congested areas (as is the case at the site of Khirbat alsamra Khirbet Khaw). (Abu-dayeh 1986: 182 - 185). This should be used in the benefit Shabib Palace case which is located in the center of the city of Zarqa, which subjected to different factors of pollution, whether it was natural or human factors but the most important factor is the exhaust of cars passing in the next street, which affects the palace in the following areas:

- 1) Distortion of stone facades and color change because of the chemicals and particle contained in cars emission.
- 2) The black sponge layer on the surface of stones, leading to the erosion of the facades and thus subjected to fall.
- 3) Vibrations resulting from the movement of vehicles around the

palace, leading to the collapse of the foundations that need maintenance and repair.

- 4) Rainwater that falls on the palace and lead to leakage within the building and increase the cracks of walls.
- water pollution: is any change in water composition, either directly or indirectly as a result of human activity, making this water less suitable for use and more dangerous in terms of its influence. Here are the most important water pollutants: 1) agricultural chemicals and especially the (DDT) and fertilizers, leading to water pollution by nitrates NO₂ and NO₃ 2) chemical detergents 3) pollution by heavy metals such as mercury, lead, arsenic and asbestos 4) solid waste pollution, such as domestic sewage The Zarqa Valley adversely affected by contaminated water, as the water flowing through Zarqa torrent and affect directly and indirectly the archaeological and heritage sites. The flow of this water during the summer and the expansion of the high water level during the winter lead to erosion of parts of the hills and archaeological sites located in the Zarqa Valley, for example, the archaeological site of Tel Al-Bireh, which is negatively affected by this flood and lead to the erosion of some stones from the site as well as the hill. (Al-Ish, 1989). And because water containing chemicals, the impact of these materials on the ancient stones and materials will cause erosion and damage taking into accounts the fact that some natural factors increase the impact of these factors, especially earthquakes and tremors, (Suyooti 1986).
 - Pollution from factories: industrial generate a large range of pollutant sources which directly emit to the air and these are: carbon monoxide, sulfur dioxide, hydrocarbons, particles. (Lazzarini and Tabassol 1998). Among the most important last five sources of material are chemical plants, organic, inorganic, iron, steel plants, paper mills, pulp and paper mills. While non-ferrous metals industry is the most important source of particles and is the second source of sulfur oxides. It is difficult to do accurate inventory of how much the reduction in pollution and the different sources. Despite the great efforts at the global level, the

situation is worse due to the growth of industry and in many cases to the failure in the application of available technological methods (Giorgio 1988) The emission of carbon dioxide alone is growing at 6-7% annually and industry at the forefront of the reasons for this. In Zarqa Governorate there are several pollution sources : chemical plants, steel plant, paper mills and factories Dulail complex, those emitted contaminants from these plants affecting the archaeological sites in the area of Wadi Ad-as well as in the eastern parts of the northern province of Zarqa (Giovanni: 1984)

Deterioration of Archaeological Sites and Cultural Heritage:

A – Erosion, b- fragmentation / weak building, c – salts, d - moisture and e-the growth of fungi and herbs.

A - Erosion: - The difference of temperature between day and night and between summer and winter, causing cracks in the stone as a result of expansion and contraction. So rainwater or acid rain leaks into the walls or inside the stone itself comprise a layer of salt on the rocks, the crust removed and will demolish all inscription or drawing on the stone. The Supreme Azraq Wetland Reserve was an example for the action of this factor, (Abu-Dayeh,1986).

B - Breakdown: - The use of chemical substances in the maintenance of historic buildings will often affects and weakens the original building, causing the chemical reaction and help in the appearance of cracks on the surface. The historic buildings suffer from the above-mentioned elements of pollution and abuse of rights due to re-use, and sometimes make additions to these buildings, which standing weight on the base, especially if the foundation is fragile or weak causing the break down and falling in many instances (Marassoyom,1985).

C - Salts: - Due to the water evaporation that seep into the walls by capillary suction either vertically or up or down, or from the surface to the inside soluble salts will crystallized , the salts will goes under physical and chemical change which in turn will damage the surface. Shabib Palace is one example of these incidents, (Giovanni 1984).

D - Humidity: - Decreasing temperature or increasing water vapor

in the air or in the surrounding of the archaeological building will increase moisture in the rock. The process done by the absorbent through capillary pores distributed across all the internal parts of the rock itself and through the intrusion (leak) of water into the rocks. Also this can be happened through the cracks on the surface or through the rising of moisture from the foundations (Seinfeld, 1985) . The absorption of steam and drops of dew that descend on the outer casing, and in all cases we find that water or moisture moving into the wall or building. It should be note that in Archaeological building the drying process start from the inside to the surface, because the last stages of internal water evaporation goes through the surface, and thus movement of salts often while pores still wet which block the pores, after crystallization and if there is a new absorption process it will be difficult to the process of evaporation. So crystals will break down the crust itself, (Massari, 1977).

E - Biodeterioration is usually linked to environmental conditions, for example, moisture, temperature and light. Air pollution has influenced to some extent the colonization and growth pattern of microorganisms in polluted urban environments. Similarly buried soils are a dynamic natural habitat for microorganisms, invertebrates and roots; accordingly, soil organisms play key roles in maintaining soil structure as well as influencing decomposition. There is an intricate relationship between the physicochemical conditions, of and the biological communities in soils. Biodeterioration can be controlled by modifying environmental conditions and the supply of nutrients. Most conservation works on cultural heritage monuments use conventional biocides which may not be suitable for the unknown and complex microbial communities. Some biocides can conceivably accelerate deterioration. Probably 90 % or more of the microorganisms present in cultural assets remain undiscovered and their influence on cultural heritage remains unknown. As a result rational use and development of biocides has not been possible. Also oxidation affecting the rock and caused damage, for example corrosion resulting from the use of steel in strengthen of archaeological buildings in Zarqa valley. (Stambolov and De Borer 1976)

Recommendations

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-Long before the use of the term ‘sustainable development’ gained currency, activities relating to the protection of cultural heritage formed an integral part of sustainability practices. The re-use of old buildings, the recycling of materials, the awareness of the fragility of air, land and water and that energy is not a limitless resource, and the involvement of local communities in decisions affecting heritage are as fundamental to heritage conservation as they are to sustainable development. It is important that the link between heritage conservation and sustainable development is publicly and permanently recognized.

-Education has a key role in bridging the gap between research and conservation practice. Currently the use of research results by conservation practitioners is arbitrary. Communication of scientific research to future practitioners does not form a formal part of education and training courses. It seems to depend on the interest and scientific competence of the teacher as to whether up-to-date information is included in course curricula. Furthermore, practitioners do not see the relevance to their work of sophisticated scientific research carried out in research institutions and universities.

- The table below highlights the main sources of pollution for different archaeological sites and cultural heritage.

Table (1) Types of Polluted Archeological sites and cultural heritage

Number	City/provinces	Sites	Pollution source	Pollution type
1	Zarqa	Al hashemia	Oil refinery	Gases, smoke and particles
2	Zarqa	Halabat	Cement Factory	Dust and dirt
3	Zarqa	Abo Sayah	Dump waste	Gases, smells and dirt
4	Zarqa	Zarqa Valley	Zarqa River	Erosion and smells
5	Zarqa	Ish Valley	Quarry	Dust and dirt
6	Zarqa	Khirbit-el samra	Treatment plant	Gases and smells
7	Zarqa	City Center	Traffic	Auto emission
8	Zarqa	North Azraq	Heavy Traffic	Vibration and Auto emission
9	Zarqa	South Azraq	Fire	Color change and distortion

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