INTERNATIONAL JOURNAL
OF
CONSERVATION SCIENCE
ISSN: 2067-533X Volume 1, Issue 2, April-June 2010: 83-92 www.ijcs.uaic.ro

ARE BIRDS A MENACE TO OUTDOOR MONUMENTS?

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Abstract:

Preliminary results of laboratory tests on real samples have shown that the uric acid which is found in bird droppings has a negative influence on metals. Results of experiments have confirmed that the damage is significant when considering the cultural heritage, statues or monuments.

Keywords: birds, bird droppings, metal, statues, corrosion

Introduction

Wild pigeons are well adapted to survive in a modern city. You see them flying over buildings, landing on the heads of statues or flying away from children in the parks. Some tourists stop, take pictures, and feed them breadcrumbs or seeds. Consequently, the birds have become accustomed to the presence of people and have started to take more and more of our space. Gulls and crows have always been a major nuisance to waste disposal areas.

Fig.1. Galati rubbish dump

In order to interpret the influence of bird droppings on monuments and statuary groups, it is necessary to understand some aspects of their digestive tract. Birds have a cloacae which they

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open when relaxing the muscles so as to eliminate its content and where the output of the intestines is collected, the liver, pancreas tract and the two ureters open (from the kidney).

Their droppings may carry a range of severe diseases to humans and, because of their acidity, they can damage buildings and historical monuments.

Outdoor monuments and the dangers to which they are exposed

Outdoor sculptures are often bronze statues and they certainly are part of our urban landscape. The most common types include human figures, landscape art, battle scenes, animals, weapons, or decorative elements.

Bronze is an alloy based on copper, which is used for carving and ornamental purposes because of its resistance to corrosion [1,3]. It is a combination of approximately 90% Copper (Cu) and 10% Tin (Sn), but there are three major classes or types of "bronze", used in sculpture and constructions. Those types are:

– *Bronze statues*, with 97% Copper (Cu), 2% Tin (Sn) and 1% Zinc (Zn);
– *Bronze architecture*, with 57% Copper (Cu), 40% Zinc (Zn) and 3% Lead (Pb);
– *Commercial bronze*, with 90% Copper (Cu) and 10% Zinc (Zn).

Once it is cast, bronze has a light brown color (# CD7F32), but it is rarely seen in this state due to oxidation. It usually presents signs of corrosion / oxidation, so that its color normally ranges from light green to dark brown [2].

The integrity and the structure of the monuments, regardless of their nature, can be affected in time by various environmental factors; this is why their maintenance and conservation have recently become very important activities [5, 6, 8].

Among the risk factors that may cause damage are:

– The human factor;
– The biological factor;
– The physical - chemical factor;
– Natural disasters.

The monuments are exposed to a wide range of chemical and physical environments (acid rain, acid particles, bird droppings), and they are also likely to be damaged by vandalism (graffiti, paint, theft).

Among air components, oxygen can alter almost all metal objects, with the exception of gold. When oxidation occurs with outdoor objects made of bronze the result is a thin layer of copper oxide on the surface of brown bronze.

Some gases, especially the sulfurous ones, in the industrialized and polluted areas, may also alter bronze objects. The effect is the appearance of green spots on the exposed surfaces.

Chlorine reacts with the copper in bronze and the result is copper chloride. The main effect is the appearance of pitting, which is an attack on the metal surface in specific areas and it may go unnoticed if the process takes place under a barrier coating or a crust which is apparently a protective layer.

It was established that pigeon droppings, of all bird droppings, is the most acid and that it attacks metal objects, accelerating the process of corrosion and deterioration. This is mainly because of the uric acid, the main constituent of bird urine, which affects copper or bronze objects, but the real chemical effect on metal surfaces remains an issue which has not yet been thoroughly studied.

The damage that the birds can cause to monuments is very severe (Fig 2).

Fig. 2. A bird-soiled statue

Methods and materials

The research presented in this paper deals with the problem of corrosion of statues made of bronze or other alloys and which are located outdoors. The study focuses on damages caused by the birds living in the geographical area of Galati.

An approach of theoretical information was used in order to identify the factors that influence the phenomenon of corrosion. We have established the research method.

Uric acid is a heterocyclic compound of carbon, nitrogen, oxygen and hydrogen with the formula $C_5H_4N_4O_3$.

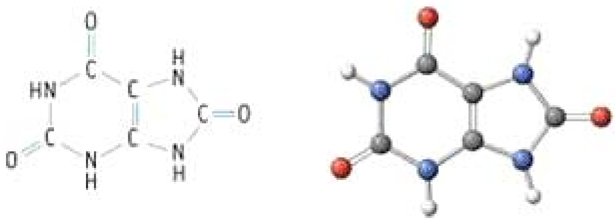
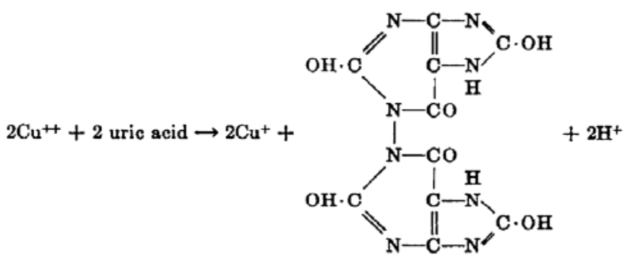


Fig.3. Chemical structure

The uric acid at alkaline pH undergoes a process of oxidation in the presence of catalytic amounts of Copper. The initial product of oxidation is analogous to dehydroascorbic acid or cystine, named dehydro uric acid [7, 10, 11].



The hydrogen eliminated from the uric acid is probably oxidized as H_2O_2, as in the reaction:

$$2Cu^{+} + 2H^{+} + O_2 \rightarrow 2Cu^{++} + H_2O_2$$

At a pH 8,2, absorption is less noticeable, but once the pH increases, it makes the oxidation rate rapidly augment up to a pH of 12,4.

The activation energy of the Copper – uric acid - O_2 system is of 70935 J/mol, a number which sustains the formation of a relatively stable addition compound [11, 12].

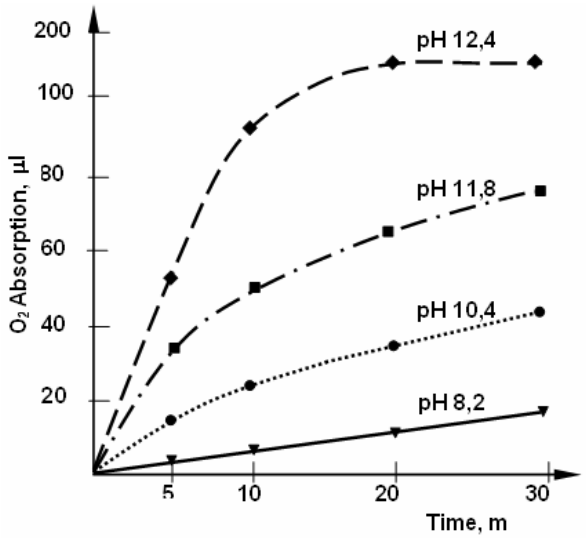


Fig. 4. Copper oxidation rate

The method: A total of 5 kilos of bird droppings was collected from 35 domestic pigeons in various locations in the Şendreni area, Galați County from February to March 2010 in order to obtain a representative sample for the present study, after previous grinding and mixing.

Fig. 5. Bird droppings

That sample underwent a 48 hours open air drying process in order to improve its flow properties.

A quantity of 1,2 kilos (±0,1 kg) of the sample material was used. It was arranged in 12 piles weighing 100g (±0,05g) each. After that 4 samples were formed as follows:

(1 + 4 + 8) – sample A (300 g);
(2 + 5 + 9) – sample B (300 g);
(3 + 6 + 10) – sample C (300 g);
(7 + 11 + 12) – sample D (300 g);

The mixing was done manually, followed by an electrical homogenization (Fig 7).

Fig.6. Mixing the sample

The material was dissolved into 200 ml of distilled water in each glass, and after complete homogenization the PH level was determined for each glass. Each sample was put in four glasses (Fig. 8).

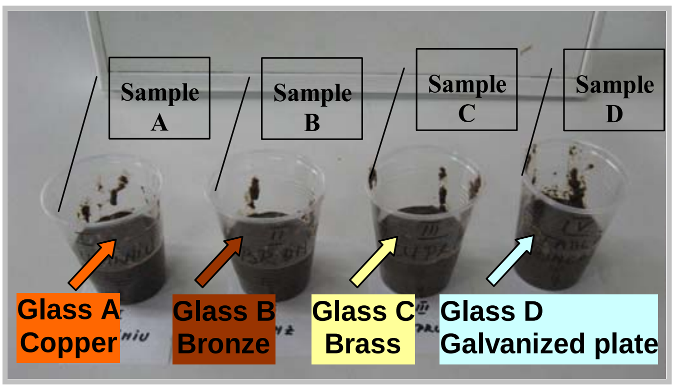


Fig.7. The samples division

Metal samples were introduced in the homogenized material as follows:

Glass A COPPER;
Glass B BRONZE;
Glass C BRASS;
Glass D GALVANIZED PLATE.

Fig.8. The determination of the pH

Four different metals were weighed using an analytical scale (± 0,0001g); the results are presented in Table 1.

Table 1. Chemical composition of the samples

Sample	**Chemical Composition**, [%]					**Mass** [grams]
	Cu	Zn		Si	Pb	
Copper 1	99.83	-	-	0.17	-	2.7755
Copper 2	99.67	-	-	0.33	-	3.0115
Bronze	92.21	1.67	3,12 (Sn)	-	3.00	14.1297
Brass 1	63.74	35.11	-	0.50	-	5.2894
Brass 2	79.98	14.56	-	0.74	-	6.1070
Galvanized Plate 1	-	71.48	28.52 (Fe)	-	-	2.1837
Galvanized Plate 2	-	79.84	20.17 (Fe)	-	-	3.4042

In order to prevent galvanic corrosion, the metal samples were suspended in the glasses using electrically isolated connections.

The samples were maintained in the glasses as follows:

- 3 days W + MS
- 1 week W + MS
- 3 weeks W + MS
- 2 months W + MS

* W – weight; MS – microscopic surface.

After a period of time in accordance with the research programme, the metal samples were evaluated visually, compared with their initial weight and micrographs were produced. The obtained data was centralized and processed.

Fig. 11. The metal samples

Table 2. The percentage of weight loss of the affected metals

Sample	U.M.	Mass				
		0 days	3 days	7 days	21 days	60 days
Cu 1	[g]	2.7755	2.7755	2.7754(9)	2.7751(2)	2.7747(3)
	%	100.00%	100.00%	99.9992794117	99.9859485284	99.9718970568
Cu 2	[g]	3.01151	3.0115	3.0114(8)	3.0114(6)	3.0114(2)
	%	100.00%	99.9996679407	99.9990038220	99.9983397033	99.9970114660
Bronze	[g]	14.12974	14.1297(4)	14.1297(3)	14.1297(1)	14.1296(9)
	%	100.00%	100.00%	99.9999292273	99.9997876819	99.9996461364
Brass 1	[g]	5.28945	5.2894(4)	5.2894(3)	5.289(4)	5.2893(8)
	%	100.00%	99.9998109444	99.9996218889	99.9990547221	99.9986766110
Brass 2	[g]	6.10702	6.1070(1)	6.1069(9)	6.1069(6)	6.1069(4)
	%	100.00%	99.9998362540	99.9995087620	99.9990175241	99.9986900321
Galvanized Plate 1	[g]	2.18374	2.1837(3)	2.1837(1)	2.1836(7)	2.1836(3)
	%	100.00%	99.9995420700	99.9986262101	99.9967944902	99.9949627703
Galvanized Plate 2	[g]	3.40422	3.4042(2)	3.4042	3.4041(8)	3.4041(2)
	%	100.00%	100.00%	99.9994124939	99.9988249878	99.9970624695

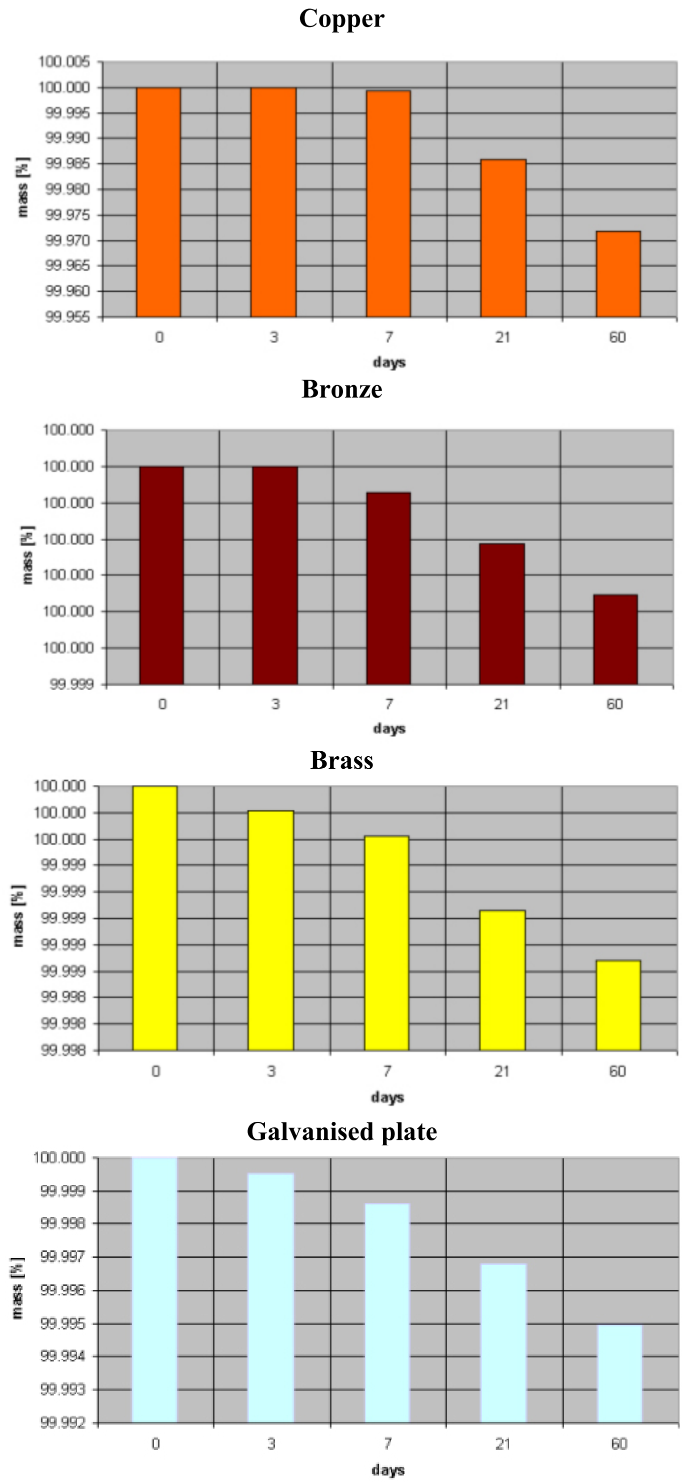


Fig. 10. Graphics of the percentage of weight loss of the affected metals

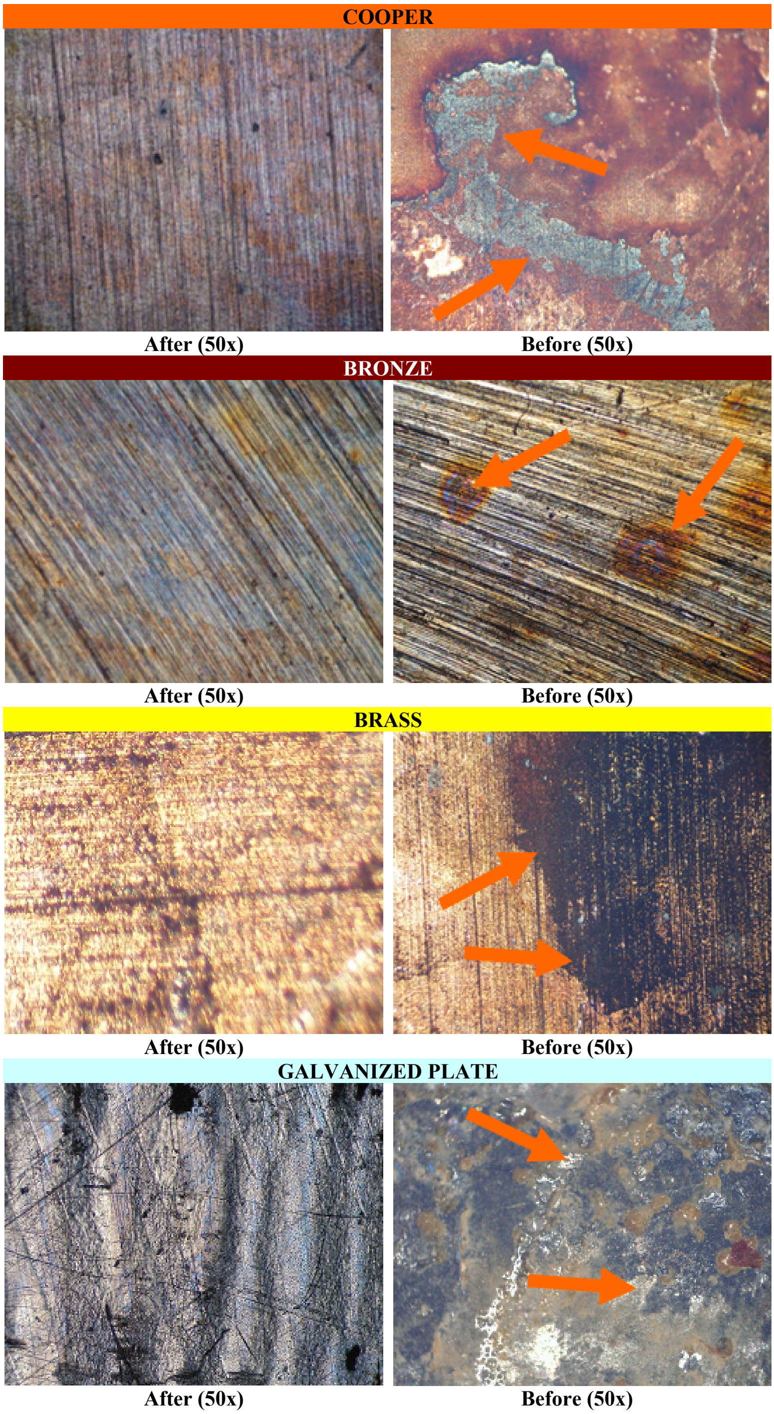


Fig. 11. The corroded surfaces (after, before)

Conclusions

Generally, the results of the study confirm that significant chemical reactions were triggered by bird droppings on objects which belong to the cultural heritage and are located outdoors, such as statues, metal monuments, and historic buildings.

Preliminary laboratory results and tests of the samples revealed that the superficial layers of copper are subject to corrosion due to the uric acid and that metal surfaces are altered.

The natural protection layer formed on the surface of bronze and copper statues also interacts with the uric acid in time, even if it seems to offer a certain protection to bird droppings.

The results of this study could lay the foundation for further evaluations and field investigations. They could also be of practical use to the people working in the sculpture conservation department.

The answer to the question in the title is: ***YES!!! Bird droppings can cause extensive damage to monuments and statues***.

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Received: May 1, 2010
Accepted: May 16, 2010