

# AIR QUALITY MONITORING FOR JORDANIAN MUSEUMS, STORAGES AND ARCHIVES



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# OBJECTIVES

- Objects at Jordanian museums suffer from deterioration and destruction caused by the different surrounding environmental parameters and by mishandling.
- This study seeks to identify those environmental factors and to replace them with the suitable environmental conditions for the objects displayed or stored, using proper methods which will contribute to the stabilization of these objects.
- Finding out the proper way for displaying and storing objects in their custody.

# INTRODUCTION

## ➤ Environmental factors

- Temperature
- Humidity
- Light
- Particulates (Dust)
- Microorganisms
- Gaseous pollutants

Among these, Gaseous pollutants consider being the most destructive agent

# GASEOUS POLLUTANTS

- Sulfur dioxide  $\text{SO}_2$
- Ozone  $\text{O}_3$
- Nitrogen dioxide  $\text{NO}_2$
- Chlorine  $\text{Cl}_2$
- Hydrogen chloride  $\text{HCl}$
- Acetic acid  $\text{CH}_3\text{COOH}$
- Formaldehyde  $\text{HCHO}$



# THE JORDANIAN MUSEUMS



# Alsalt Archaeology Museum

## 1986



# Dar Alaraya Museum

## 1886 (1994)





# Department of Antiquities (Storage & Archive) 1982



# Karak Museum

## 1142 (1980)





# Madaba Archeology Museum

## 1978



# Madaba Folklore Museum 1978



# Museum of Jordanian Heritage 1988



# Numismatics Museum 2002



# Petra Museum

## 1994







# Umm Qies Museum 1987



# Why these museums were selected?

- Representing the different **geographic** and **climatic** zones.
- Representing all **types of materials** kept or displayed at the Jordanian museums.
- Representing all types of museum **buildings** in Jordan.

# METHODS

## 1- Purafil Environmental Reactivity Coupons (ERCs)



## 2- Purafil Environmental Reactivity Monitors (ERMs)



# The Purafil Environmental Reactivity Coupons (ERCs)

How and where these coupons were installed?

# Hung inside showroom



Placed inside showcases



Set at the make up air source  
“in some museums”





# ANALYZING THE COUPONS

Done by  
Purafil, Inc

Utilizing  
The electronic cathodic reduction method

## Common levels of gaseous pollutants

Pollutant	Normal Background Concentrations	Peak Concentrations (Urban Areas)
Sulfur dioxide	6-30 ppb	100-750 ppb
Ozone	0.4 ppb	20-40 ppb
Nitrogen dioxide	1.0-1.5 ppb	40-100 ppb
Chlorine	0.06-0.6 ppb	20-130 ppb
Hydrogen chloride	20-50 ppb	200-450 ppb
Acetic acid	4-10 ppb	20-100 ppb
Formaldehyde	3-15 ppb	10-40 ppb
Hydrogen sulfide	5-10 ppb	100-500 ppb

Ministry of Housing. *Advisory Guide-Line Air Quality Archives*, Delta Plan for Culture Preservation, Spatial Planning and the Environment, Government Buildings Agency, The Hague, The Netherlands, 1994.

ENVIRONMENTAL CLASSIFICATION FOR PRESERVATION ENVIRONMENTS					
Silver Corrosion			Copper Corrosion		
Class	Air Quality Classification	Corrosion Amount	Class	Air Quality Classification	Corrosion Amount
S1	Extremely Pure	< 40Å / 30 days	C1	Extremely Pure	< 90Å / 30 days
S2	Pure	< 100Å / 30 days	C2	Pure	< 150Å / 30 days
S3	Clean	< 200Å / 30 days	C3	Clean	< 250Å / 30 days
S4	Slightly Contaminated	< 300Å / 30 days	C4	Slightly Contaminated	< 350Å / 30 days
S5	Polluted	≥ 300Å / 30 days	C5	Polluted	≥ 350Å / 30 days

### AIR PURITY REQUIREMENTS

**Archives, Metal Collections, Rare Books: Class S1/C1**

**Museums, Museum Storage, Libraries: Class S2/C2**

**Historic Houses: Class S3/C3**

**Short Term Acceptable: Class S4/C4**

**Not Acceptable: Class S5/C5**

ISA Standard ANSI/ISA-S71.04-1985. *Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants*, International Society for Measurement and Control, Research Triangle Park, NC, 1986.

## General reactivity monitoring acceptance criteria

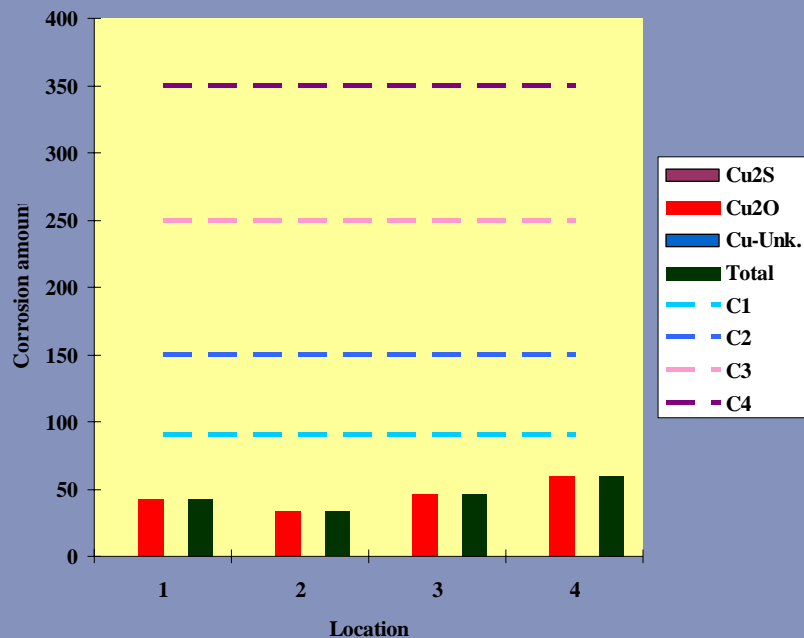
Silver Reactivity Acceptance Criteria		Copper Reactivity Acceptance Criteria	
Silver Corrosion Reaction Products	Corrosion Film Thickness	Copper Corrosion Reaction Products	Corrosion Film Thickness
<i>Silver Chloride, AgCl</i> Silver Sulfide, Ag <sub>2</sub> S Silver Oxide, Ag <sub>2</sub> O	0Å / 30 days <50Å / 30 days <50Å / 30 days	<i>Copper Sulfide, Cu<sub>2</sub>S</i> Copper Oxide, Cu <sub>2</sub> O Copper Unknowns	0Å / 30 days <150Å / 30 days 0Å / 30 days
Total Silver Corrosion	<100Å / 30 days	Total Copper Corrosion	<150Å / 30 days

ISA Standard ANSI/ISA-S71.04-1985. *Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants*, International Society for Measurement and Control, Research Triangle Park, NC, 1986.

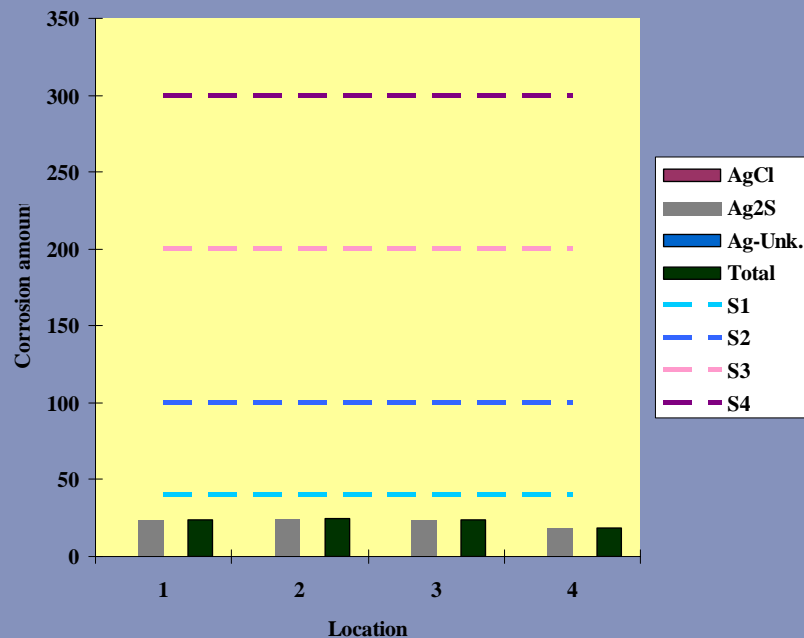
# RESULTS

# Alsalt archaeology museum

Alsalt archaeology museum



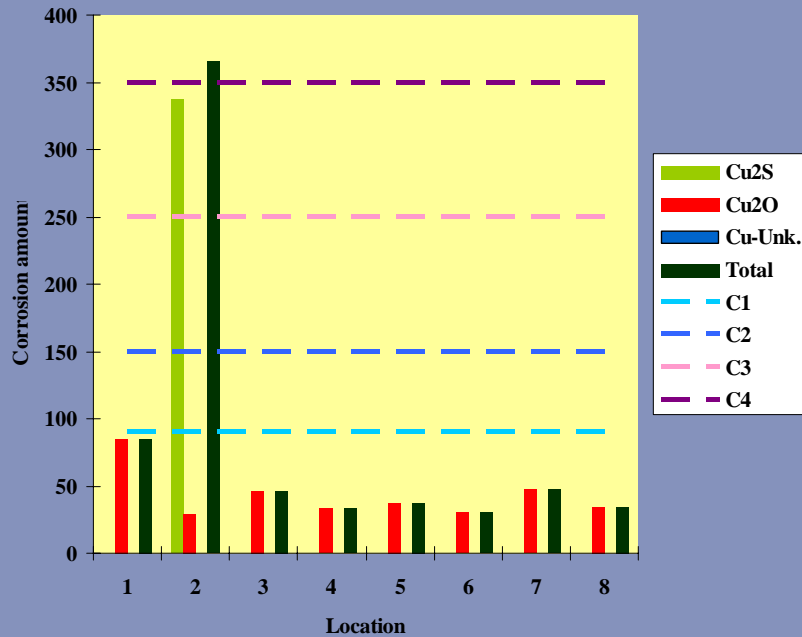
Alsalt archaeology museum



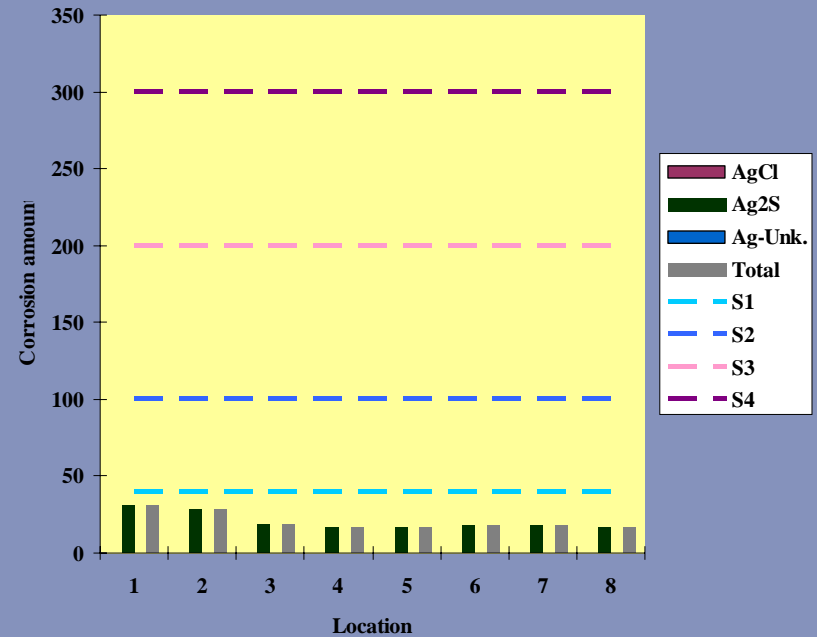
Delineate the locations of the coupons in the Salt museum.		
Location number	description of location	The coupon code
1	Entrance	SM 4
2	Late Bronze Age Hall	SM 3
3	Hellenistic -early Islamic Hall	SM 2
4	The Rural Landscape Middle Islamic	SM 1

# Dar Alsaraya museum

Dar Alsaraya museum



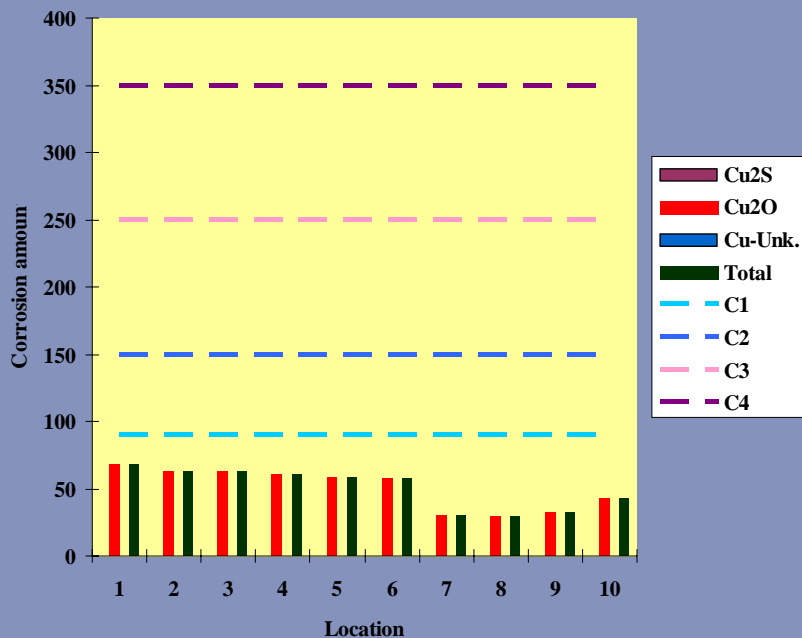
Dar Alsaraya museum



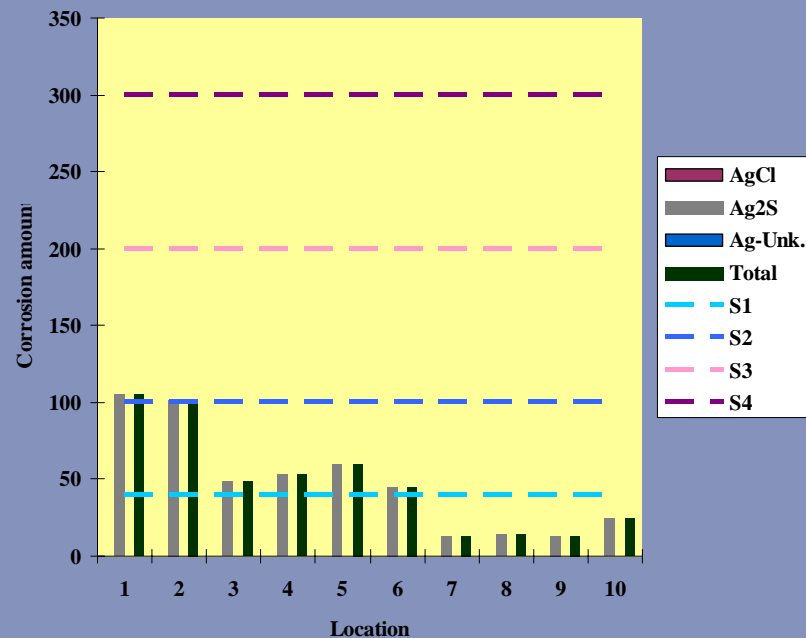
Delineate the locations of the coupons in the Dar Alsaraya museum.		
Location number	description of location	The coupon code
1	Mosaic Hall	DSM 6
2	Ancient Period Hall	DSM 1
3	Islamic Period Hall inside case (glass case)	DSM 4
4	Metallurgy room inside case	DSM 2
5	Inside case	DSM 7
6	Outdoor	DSM 8
7	Classical periods hall	DSM 3
8	Sculptures Hall	DSM 5

# Department of Antiquities, Storage and Archive

Department of antiquities



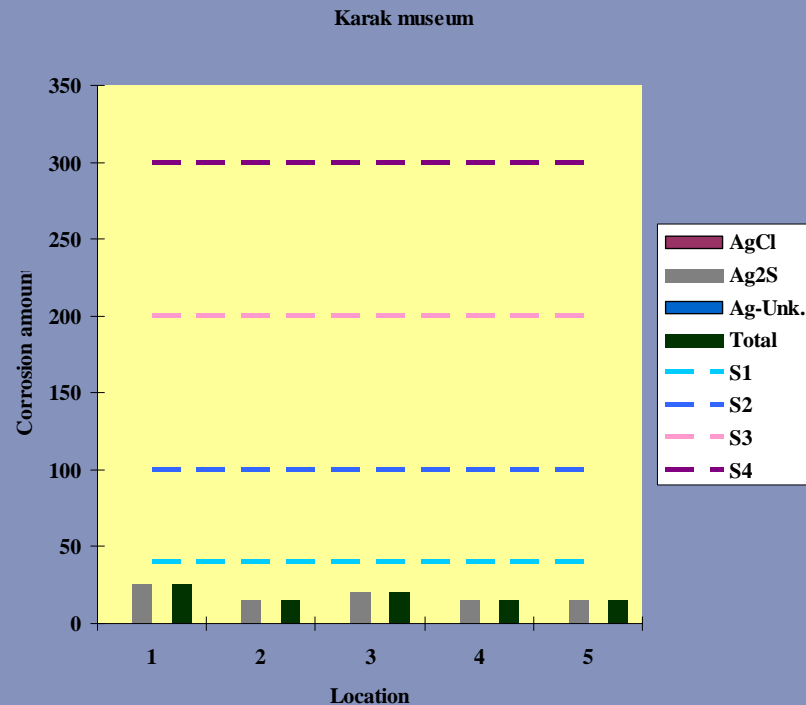
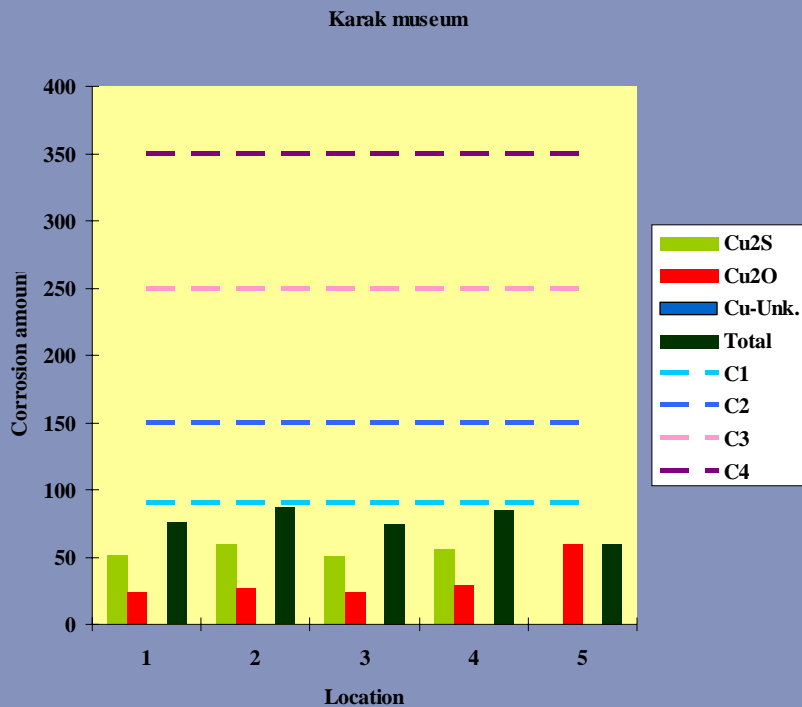
Department of Antiquities



Delineate the locations of the coupons in the Department of Antiquities (storage and archive).		
Location number	description of location	The coupon code
1	Main storage-exit	DAS 5
2	Storage no. 1	DAS 2
3	The Cave-inside	DAS 7
4	Main storage, Entrance	DAS 3
5	The Care-Entrance	DAS 6
6	Main storage ,back	DAS 4
7	Archive Drawers	DAA 2
8	Storage	DAS 1
9	Archive	DAA 1
10	Archive Closet	DAA 3



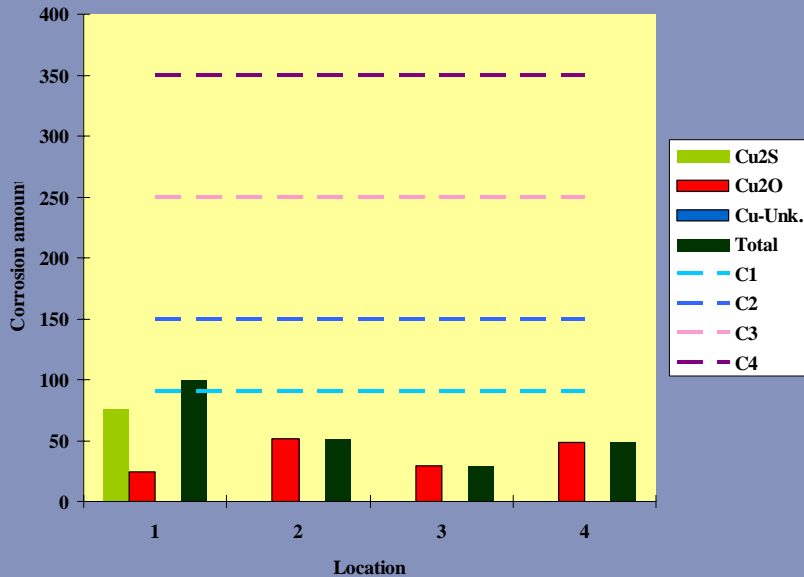
# Karak museum



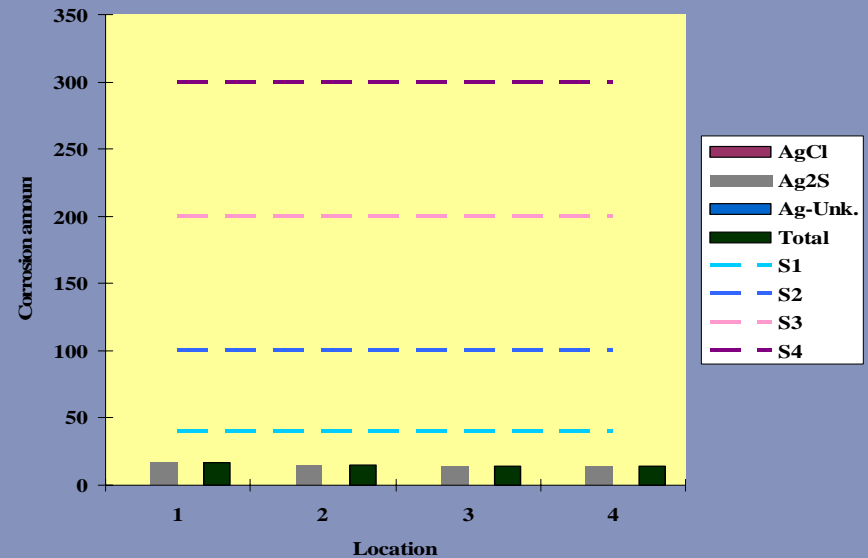
Delineate the locations of the coupons in the Karak museum.		
Location number	description of location	The coupon code
1	Main Hall entrance	KM 1
2	Entrance	KM 4
3	Main Hall back side	KM 3
4	Entrance	KM 5
5	Main Hall inside closet	KM 2

# Madaba archaeology museum

Madaba archaeology museum



Madaba archaeology museum

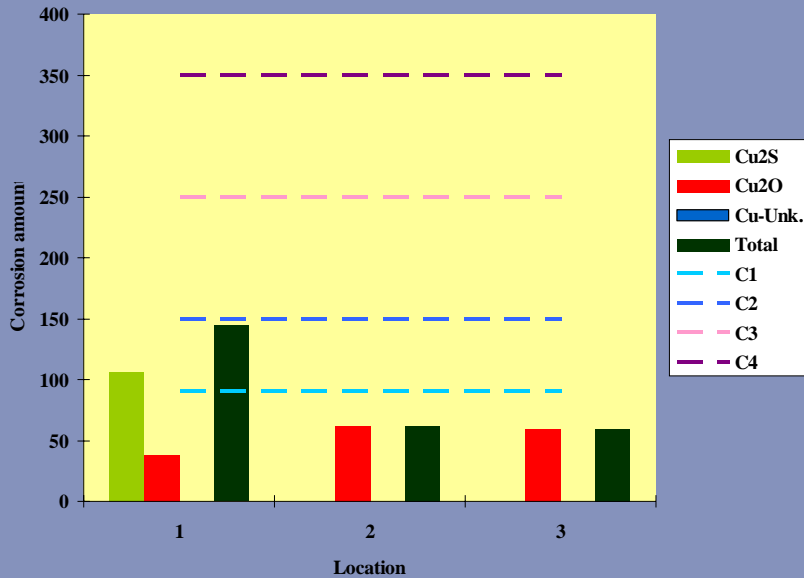


Delineate the locations of the coupons in the Madaba museum.

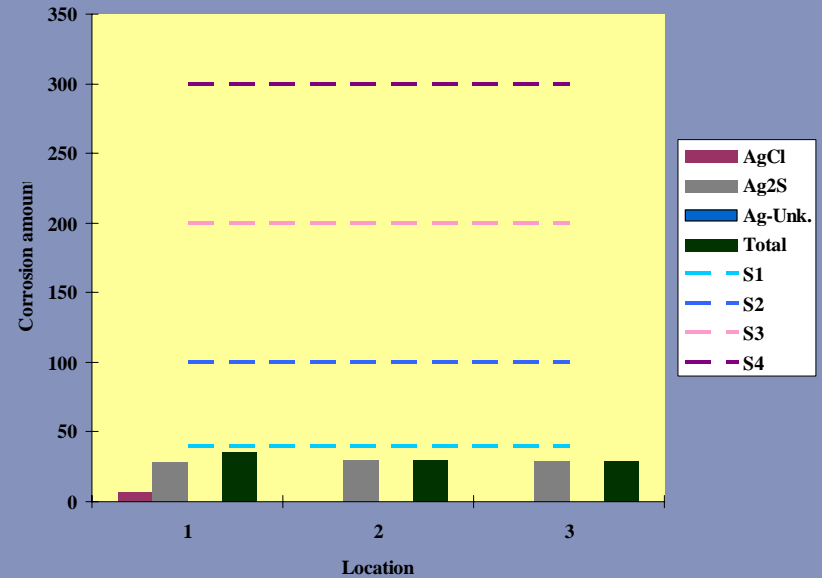
Location number	description of location	The coupon code
1	Storage	MM 6
2	Second show room	MM 5
3	In show room case	MM 7
4	Main show room	MM 4

# Madaba folklore museum

Madaba folklore museum

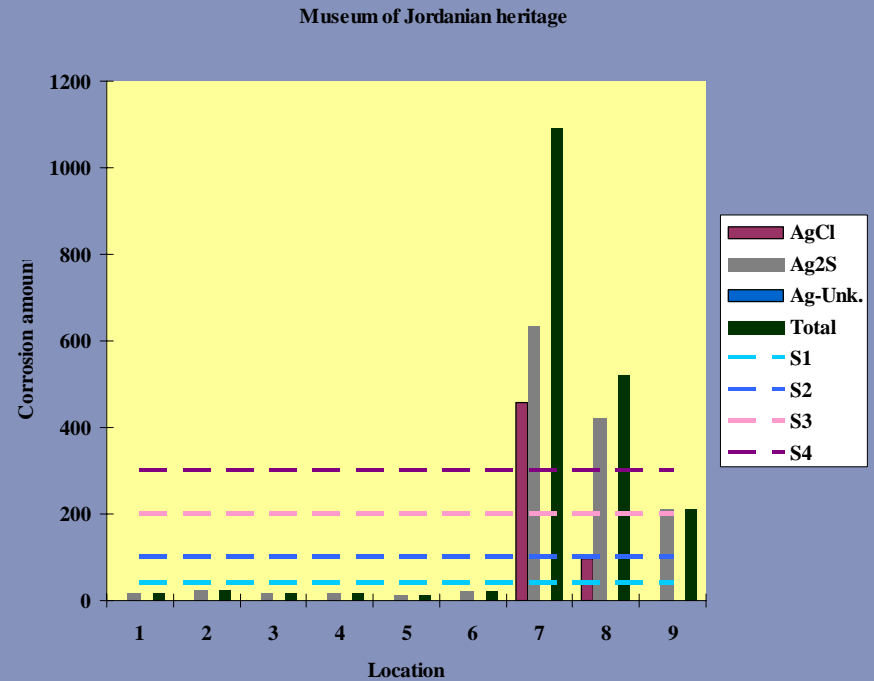
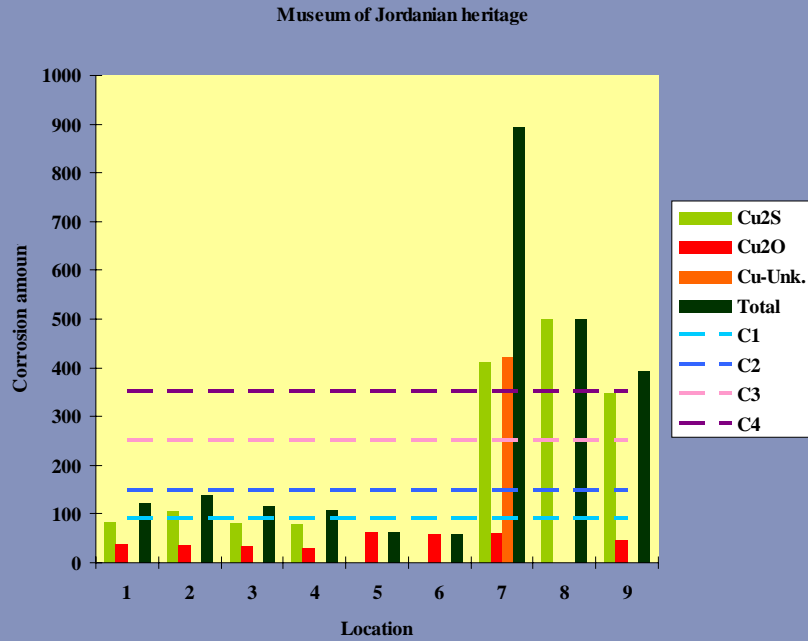


Madaba folklore museum



Delineate the locations of the coupons in the Madaba folklore museum.		
Location number	description of location	The coupon code
1	Main Hall	MM 1
2	Textile Hall	MM 2
3	Main Hall Entrance	MM 3

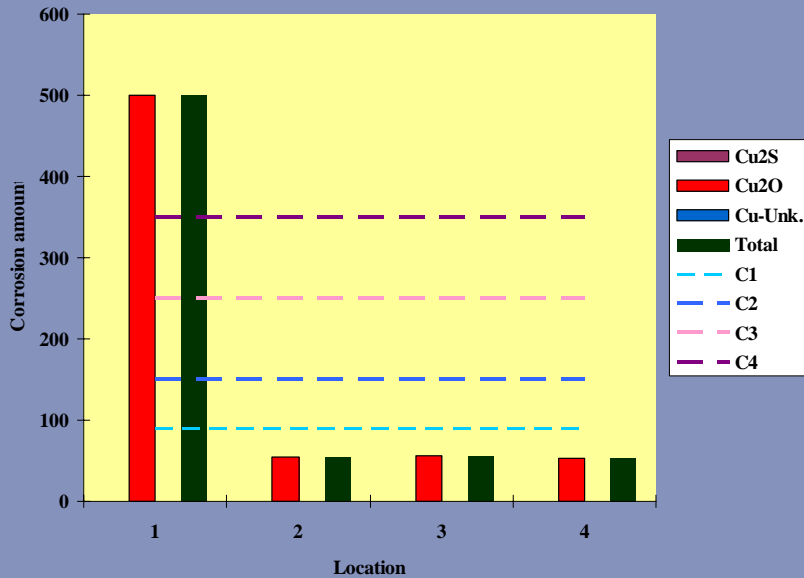
# Museum of Jordanian heritage



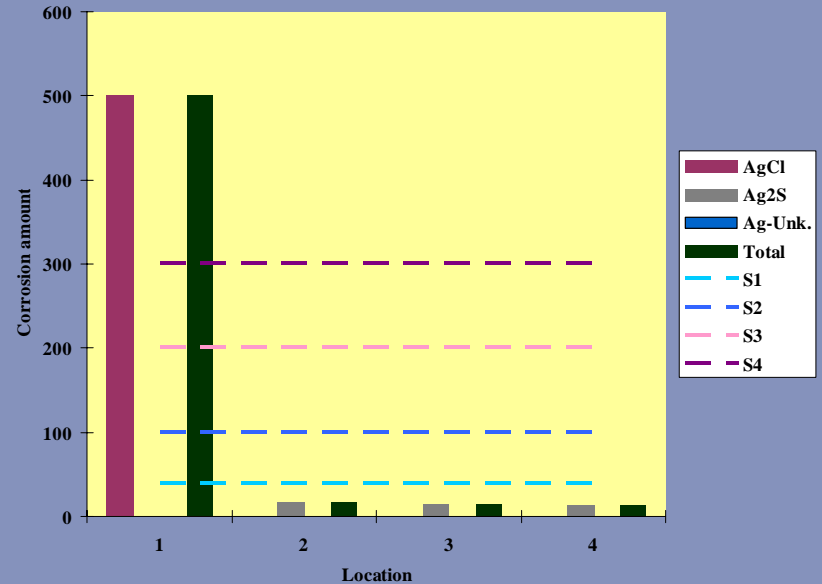
Delineate the locations of the coupons in the Museum of Jordanian heritage.		
Location number	description of location	The coupon code
1	Inside show case Lead Sarcophagus	MJH 7
2	Peasant house	MJH 9
3	Warehouse (storage)	MJH 10
4	Inside show case	MJH6
5	Entrance	MJH 5
6	Forth hall Islamic period objects	MJH 8
7	Outside air	MJH11
8	Indoor courtyard	MJH12
9	First hall	MJH13

# Numismatics museum

Numismatics museum

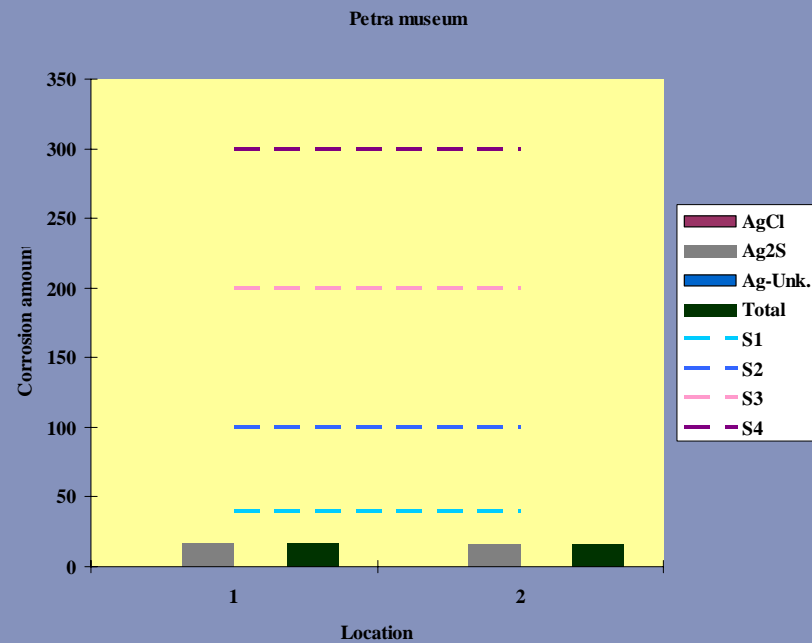
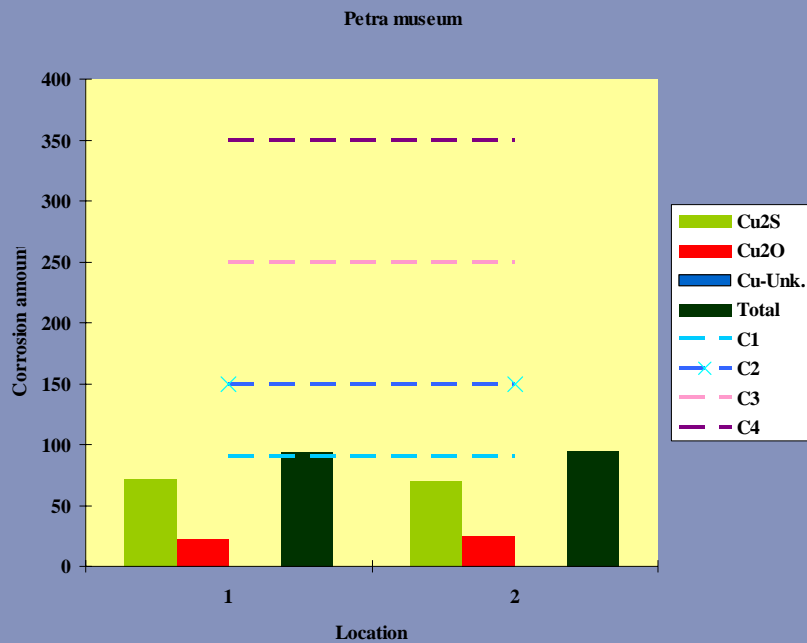


Numismatics museum



Delineate the locations of the coupons in the Numismatics museum.		
Location number	description of location	The coupon code
1	Outside air Yarmouk	MJH 4
2	Main Hall Yarmouk Entrance	MJH 1
3	Main Hall Yarmouk Far corner from entrance	MJH 2
4	Main Hall Yarmouk Out coming air from (ac)	MJH 3

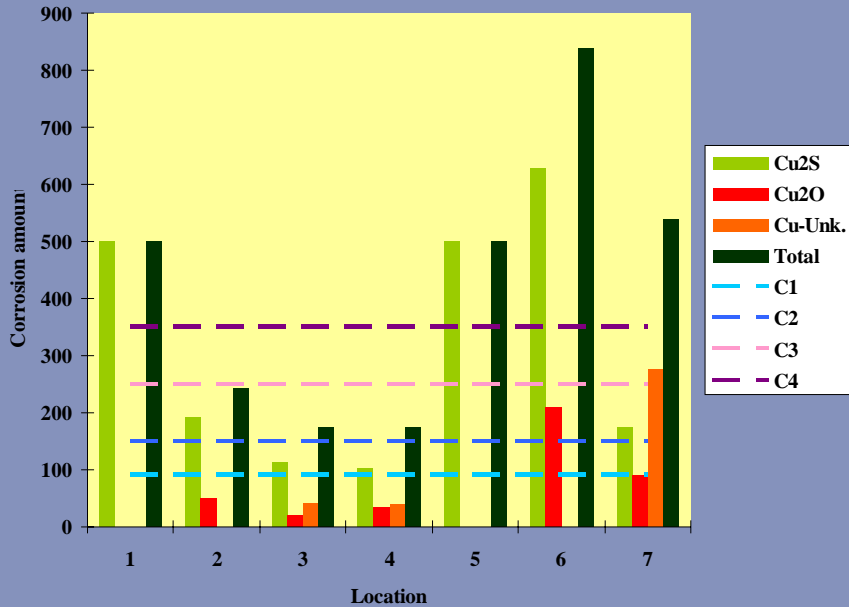
# Petra museum



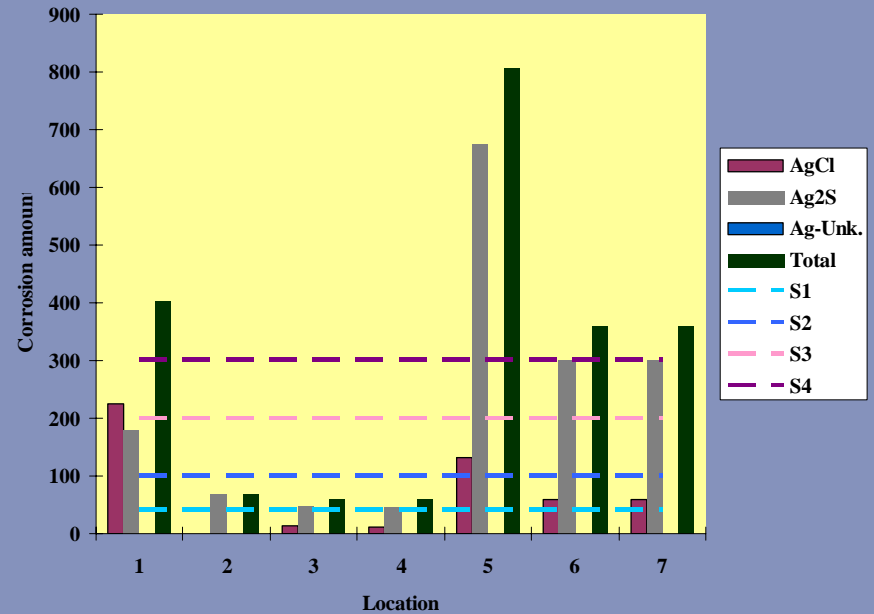
Delineate the locations of the coupons in the Petra museum.		
Location number	description of location	The coupon code
1	Second Hall	PM 2
2	First Hall	PM 1

# Umm Qeis museum

Umm Qeis museum



Umm Qeis museum



Delineate the locations of the coupons in the Umm Qeis museum.		
Location number	description of location	The coupon code
1	Outside air	UQM1
2	Main Hall	UQM4
3	Sculpture Hall	UQM2
4	Sculptures Hall	UQM3
5	First showroom	UQM5
6	Second showroom	UQM6
7	Second showroom	UQM7

# CONCLUSIONS

- If the general reactivity monitoring acceptance criteria of **S2/C2** is met, it is generally accepted that this environment may be sufficiently well-controlled as to prevent the decay/deterioration of objects and artifacts - except in cases where active sulfur and/or chlorine contamination is present – although, for archives, metal collections, and rare book storage where a Class **S1/C1** is the recommended standard.
- The detection of sulfur and/or chlorine contamination is particularly problematic for metal collections, photographic images, various paper types, and colorants.
- The detection of a silver sulfide ( $\text{Ag}_2\text{S}$ ) film without a corresponding copper sulfide ( $\text{Cu}_2\text{S}$ ) film usually indicates the presence of oxidized forms of sulfur such as sulfur dioxide ( $\text{SO}_2$ ) and sulfur trioxide ( $\text{SO}_3$ ).



# CONCLUSIONS

- When both films are present and the amount of  $\text{Cu}_2\text{S}$  is greater than 50% of the total corrosion, this is further evidence of the presence of active sulfur compounds in the subject environment.
- The presence of chloride corrosion ( $\text{AgCl}$ ) indicates the presence of (an) inorganic chlorine compound(s), e.g., chlorine ( $\text{Cl}_2$ ), chlorine dioxide ( $\text{ClO}_2$ ), hydrogen chloride ( $\text{HCl}$ ).

<b>Differentiated of the monitored museums conditions.</b>			
<b>Museum</b>	<b>Good (acceptable)</b>	<b>Medium</b>	<b>Bad (not acceptable)</b>
<i>The Alsalt museum</i>	*		
<i>The Dar Alsaraya museum</i>		*	
<i>DoA (Storage and Archive)</i>		*	
<i>The Karak museum</i>		*	
<i>The Madaba archaeological museum</i>		*	
<i>The Madaba folklore museum</i>		*	
<i>The museum of Jordanian heritage</i>		*	
<i>The Numismatics museum</i>	*		
<i>The Petra museum</i>		*	
<i>The Umm Qeis museum</i>			*

# RECOMMENDATIONS

- It is further recommended that reactivity monitoring be continued - either with ERCs, or the OnGuard 3000 Atmospheric Corrosion Monitor.
- it is recommended to place additional sets of ERCs in the makeup air handlers and inside the facility to determine if and where these contaminants are being distributed throughout the facility.
- Hence, this research has a limited time for the measurement period, which was made at winter time, consequently, it is recommended for further investigations during the summer season, in order to compare the results and determine whether if there are any changes between the two season's results.
- Finally, it is recommended that a comprehensive air pollution research to take a place at the rest of the museums in Jordan.

# ACKNOWLEDGEMENT

- Twin Filter, Inc. Zaandam, The Netherlands
- Purafil, Inc. Georgia, USA.

**THANK YOU FOR YOUR ATTENTION**