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### during African Dust Events in the Eastern Mediterranean Elemental, Organochlorine and Bacterial Communities **Composition of Atmospheric Fine Particles**

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attributable to: In the Mediterranean Basin high aerosol loadings are

a) pollution largely derived from Europe, and b) dust carried from North Africa.







#### Lelieveld et al. (2002)

QUESTION: Can desert dust transport to the downwind areas pollutants, and host and carry microorganisms?
<u>WHO</u> : drought and dust storm activity in the sub-Saharan region of Africa cause regional outbreaks of diseases (e.g. <u>meningococcal meningitis).</u> <u>FAO</u> : toxic wastes in Africa alone amounts to around 120,000 tonnes (30% of the waste believed to be POPs).
El Niño events have coincided with increased flux of Saharan dust across the Atlantic. Prospero (2007)Saharan dust transport Mediterranean has increased. Antoine and Nobileau (2006)



Dust flux from the Saharan-Sahel region to the atmosphere ca. 1\*10<sup>9</sup> t/y

In the last decade: amplification of dust loadings.

Mineral Dust (µg m<sup>-3</sup>)

25 30 35

40 45 50

20 15

66 68

70 72 74

76 78

90 92

94 96 86

Saharan Over the dust transport over 1998-to-2004 periods the the

Dust events i	introduce a significant pulse of
microorganis	ms and other microbiological material into the
atmosphere.	Griffin (2007); Gorbushina et al. (2008)

The first report (Polymenakou et al.2008):Bacterial communities associatedwith aerosol particles of six differentsize ranges were characterized usingmolecular culture-independentmethods (analysis of 16S rRNAgenes).



## CHEMISAND Project (2012-2015)

- analytical chemical and geochemical techniques. <u>chemical content</u> in the <u>Eastern Mediterranean</u>, using advanced Determine the dust burden of fine particles and its hazardous
- Saharan Dust events. investigate the microbial composition of PM<sub>2.5</sub> during the Use the most advanced molecular biology methods to

#### Experimental Methods





Agilent 6890N HRGC/Agilent 5973 inert MSD in <u>NCI mode</u>

Diversity coverage	Nr. clones sequenced	Approach	
41-70%	489	RFLP-partial 16s sequencing	<b>Previous study</b> Polymenakou <i>et al.</i> 2008
100%	519,707	Illumina amplicon sequencing (REGIONS V3- V4)	Present study

# **Results & Discussion:**

# I) Elemental analysis

#### II) Determination of Organic **Toxic Compounds** (PAHs and POPs)

III) Microbial Communities

element	Mg	Mn	Sr	Ce	Pr	Nd
R^2	0.83	0.85	0.86	0.80	0.80	0.80

(n= 26 samples; p-value <0.05 )

R^2 coefficients: Concentrations of elements African dust PM<sub>2.5</sub> vs. total PM<sub>10</sub>

a v	2	max	min		
U.J I	2	1.41	BDL	µg/m³	Ca
0.00		0.17	0.03	µg/m³	Þ
0.00	0 00	0.15	0.03	µg/m³	Fe
0.22	2	0.39	0.10	µg∕m³	Na
0.04		0.10	0.01	µg/m³	Mg
0.04	2	0.95	0.091	µg/m³	▼
1.00	-	3.80	0.012	ng/m <sup>3</sup>	Mn
9.90	0	48.69	2.714	ng/m <sup>3</sup>	Zn
0.90		2.90	0.172	ng/m <sup>3</sup>	S
13.4	707	198.3	BDL	pg/m <sup>3</sup>	La
0.00	л 20	15.51	BDL	pg/m <sup>3</sup>	Dy
2.10	2	6.61	0.637	ng/m <sup>3</sup>	Pb
0.01	2	0.03	BDL	ng/m <sup>3</sup>	Th

I-A) Concentrations of major and trace elements of PM<sub>2.5</sub> during African dust

max min av hd/m3 Ca 9.95 1.51 BD hd/m<sub>3</sub> 0.95 Þ 5.25 0.03 µg/m<sup>3</sup> Fe 0.64 0.04 2.75 hd/m<sub>3</sub> Na 0.70 BDL 2.11 hd/m³ hd/m³ ud/m³ <u>g</u> 0.38 BDL 1.86 0.50 ス 0.06 1.46 Mn 9.32 11.49 42.44 0.18 ng/m³ ng/m³ N 50.45 BDL 6.81 25.42 လိ BDL 2433. 530.7 pg/m<sup>3</sup> La 31.63 265.4 pg/m³ ng/m³ ng/m⁵ <u>63.2</u> BDL 3.39 33.08 **Pb** BDL 0.09 Т BDL 0.59

events (n=33 samples; BDL : below limit of detection)

I-A) Concentrations of major and trace elements of PM<sub>2.5</sub> non-African dust 

events (n=16 samples; BDL :below limit of detection)





# PAHs: Potential Sources Estimation

Rotated Component Matrix<sup>a</sup>

alysis. 1alization.	nt An: Norm	al Compone ( with Kaiser	od: Princip )d: Varimax	Extraction Meth Rotation Methc
		,462	698	BghiP_log10
		,413	-893	DBA_log10
		,448	,876	IP_log10
		,507	,848	BaP_log10
ŗ		,458	-881	BeP_log10
Π		,413	-893	BkF_log10
		,451	,879	BbF_log10
		,493	855	Chr_log10
		,591	,787	BaA_log10
ס		615	,729	Py_log10
		699'	,730	Fluo_log10
		,629	,573	An_log10
		,522	,713	Phe_log10
		,273	-,700	PM_log10
		,783	-,125	EC_log10
		-835	,223	OC_log10
		-,051	-,604	Fe_log10
		,497	-863	SPAHS_log10
		- 660	-,218	WS_log10
		,240	898'-	T_log10
		2	1	
		onent	Comp	

2 statistically significant PC factors, which

are describing 82% of total data variance

using normalized [log10 transformed] data:

Principal Component Analysis

a. Rotation converged in 3 iterations.

	Source	PC Factors	
Coal / wood combustion	Gasoline / Diesel vehicles	PC1	
Dispersion		PC2	

## III) Microbial communities

### **Important Bacteria**

	<b>Previous study</b> (Polymenakou et al. 2008)	Present study		Previous study (Polymenakou et al. 2008)	Present study
A. Iwoffi	+	+	Mycobacterium		+
A. johnsonii	+	+	Providencia		+
Haemophilus	+	+	Neisseria	,	+
parainiiuenzae			Treponema	i.	+
Streptococcus pneumoniae	+	+	(low) Dermabacter		+
Streptococcus mitis	+	+	Plant/Soil		+
Sphingomonas	+	+	Rhizobacterium	a.	+
Propionibacterium	+	+	Bradyrhizobium		
acnes			Azospirillum		
Streptococcus	+	+	Ralstonia	a.	+
goracini			Xanthomonas		+
Clostridium		+	Nitrosomonas	1	+
Escherischia- Shigella		+	Nitrosospira		+
Legionella		+			
Aeromonas		+			

### **DISTRIBUTION AT PHYLUM LEVEL**





### DISTRIBUTION AT CLASS LEVEL



taxonomic units (OTUs) with ordinations from sandstorm events and control samples for 2013 and 2014: Principal coordinate analysis of bacterial communities based on relative abundances of operational



Canonical analysis of principal coordinates ordinations of bacterial communities based on relative abundances of OTUs from sandstorms and control samples from 2013 and 2014:





#### COCLUSIONS

events from the Sahara area that occurred in the Eastern fine particulate matter (PM<sub>2.5</sub> & PM<sub>10</sub>) associated with important dust Mediterranean (Island of Crete) between 2013-2014. The chemical (elemental and organic) and microbial characterization of We presented:

of the rare earth elements and actinides and crustal The <u>chemical composition</u> of the samples reflected the <u>dominance</u>

<u>elements</u> indicated the dust contained also anthropogenic material <u>elements</u>, of Saharan dust. The presence of <u>anthropogenic trace</u> differentiate Saharan dust from other dust samples. (collected during transport from Africa). <u>PAHs and POPs did</u> not

dominated by Proteobacteria at the phylum level Microbial biodiversity associated with Saharan dust was high, but Betaproteobacteria at the class level. and

gordonii, H. parainfluenzae, A. Iwoffi, A. johnsonii, P. acnes). reactions such as endocarditis (i.e., S. pneumoniae, S. mitis, S. human pathogens, linked to several diseases such as pneumonia, meningitis, and bacteremia or suspected to induce pathologic In the Saharan dust particles we detected <u>phylogenetic neighbors to</u>

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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

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