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Wet deposition in the Coast of the Gulf of Mexico

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Introduction

The commercial activities on the coast of the Gulf of Mexico are of great importance for this study (extraction processing and distribution of hydrocarbons, sea port activities, industrial, agricultural, fisheries and tourism) that make this area a potential source of air pollution.

Due to the potential negative environmental impact, acid deposition in several receptors such as: Lakes, rivers, forests, soils, materials, (monuments of cultural heritage) etc., have become a topic of research in the coastal area of the Gulf of Mexico since 1986. Archaeological monuments such as the Mayan Zone, the Archaeological Zone of El Tajín and the Fortress of San Juan de Ulúa, all of these monuments lay on the Coast of the Gulf of Mexico and were built with limestone ($CaCO_3$) which is especially susceptible to deterioration or damage by acid rain.

Since 2003 the complete annual information has been continuously studied at the four sites: 1) The Archaeological Zone of El Tajín (TAJ); 2) the Instituto de Ecología, La Mancha (LMH); 3) The Fortress of San Juan de Ulúa (SJU) in the Port of Veracruz and 4) Universidad Veracruzana, Campus Mocambo (UVM). From 2003 to 2005.

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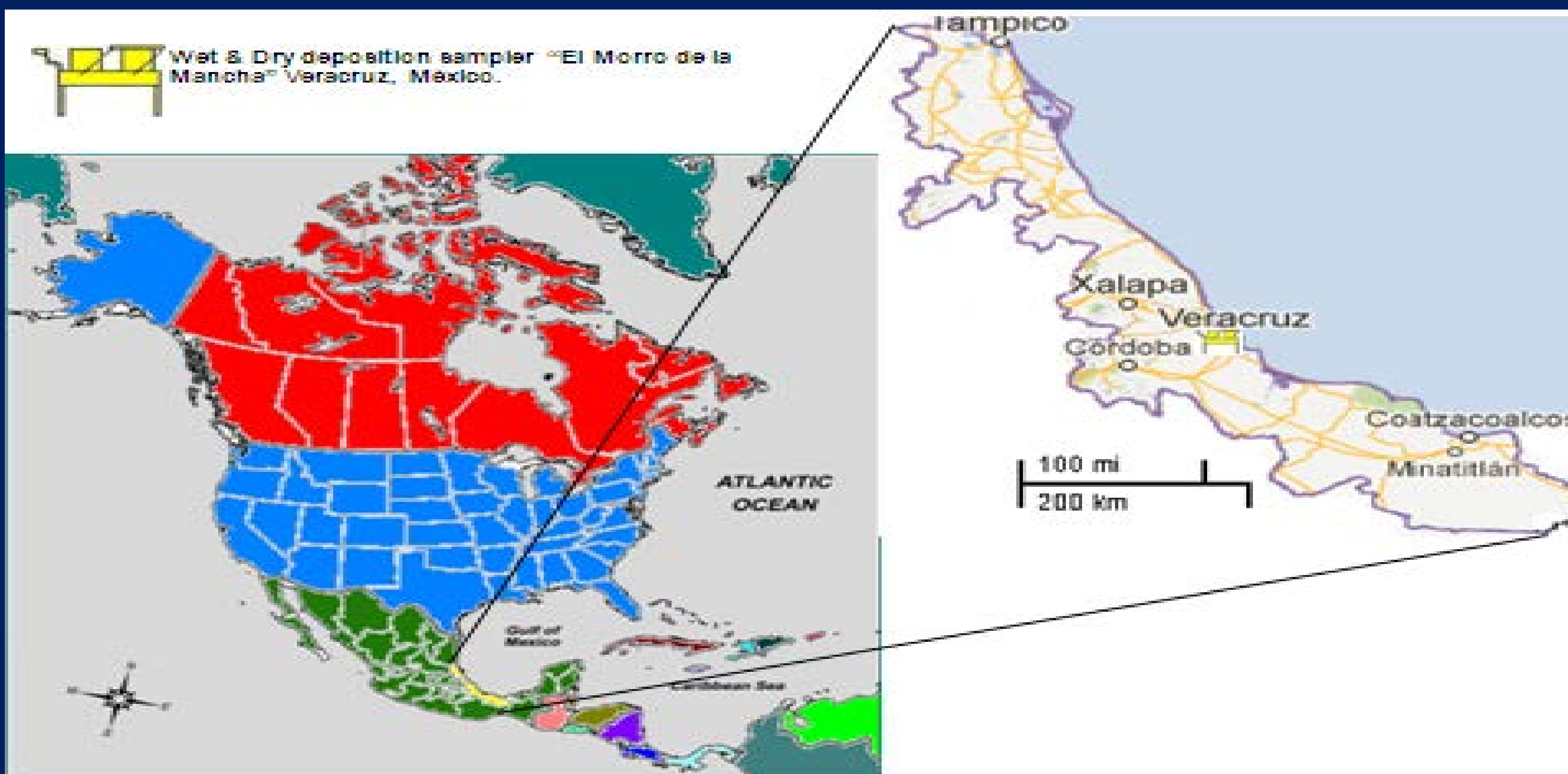
Since nine years ago, La Mancha, is still working under a strict quality assurance and quality control protocol, which makes this station a prototype for the studies in atmospheric deposition on the Coast of the Gulf of Mexico.

Methodology

Table 1. Sampling site location.

Sampling site	Location	Geographical Coordinates
Instituto de Ecología. A.C., at the Morro de la Mancha.	The sampling site is located in climatological station, located on the Coast of the Gulf of Mexico	Lat. 19º35´ 21.6¨N Long. 96º22´49.7´´W Altitude 2 m.a.s.l.

Figure 1.- Location of the site of sampling of “La Mancha”, Veracruz, Mexico.



Wet deposition sampling and analysis

The collection of rainfall took place daily to facilitate a more accurate temporal resolution for wet deposition in the study sites. Chemical analysis for each sample of rain was to determine the following parameters: pH, conductivity, cations (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}) and concentrations of anions (Cl^-, NO_3^-, SO_4^{2-}) by means of High Performance Liquid Chromatography (HPLC). These analytical methods are in line with the US-EPA protocols.

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Results

Number of samples

During the period of study (2003 to 2011) a total of 569 samples were collected in La Mancha station and analyzed at the SCA-CCA-UNAM laboratory. Table 2 shows the number of samples collected by year.

Table 2 Number of samples by year at La Mancha station

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011*
Number of samples	72	57	74	49	64	83	71	69	30
								Total	569

*Lost samples during the shipment (from August to December).

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Figure 2. Box plots for the pH values measured at “La Mancha” station.

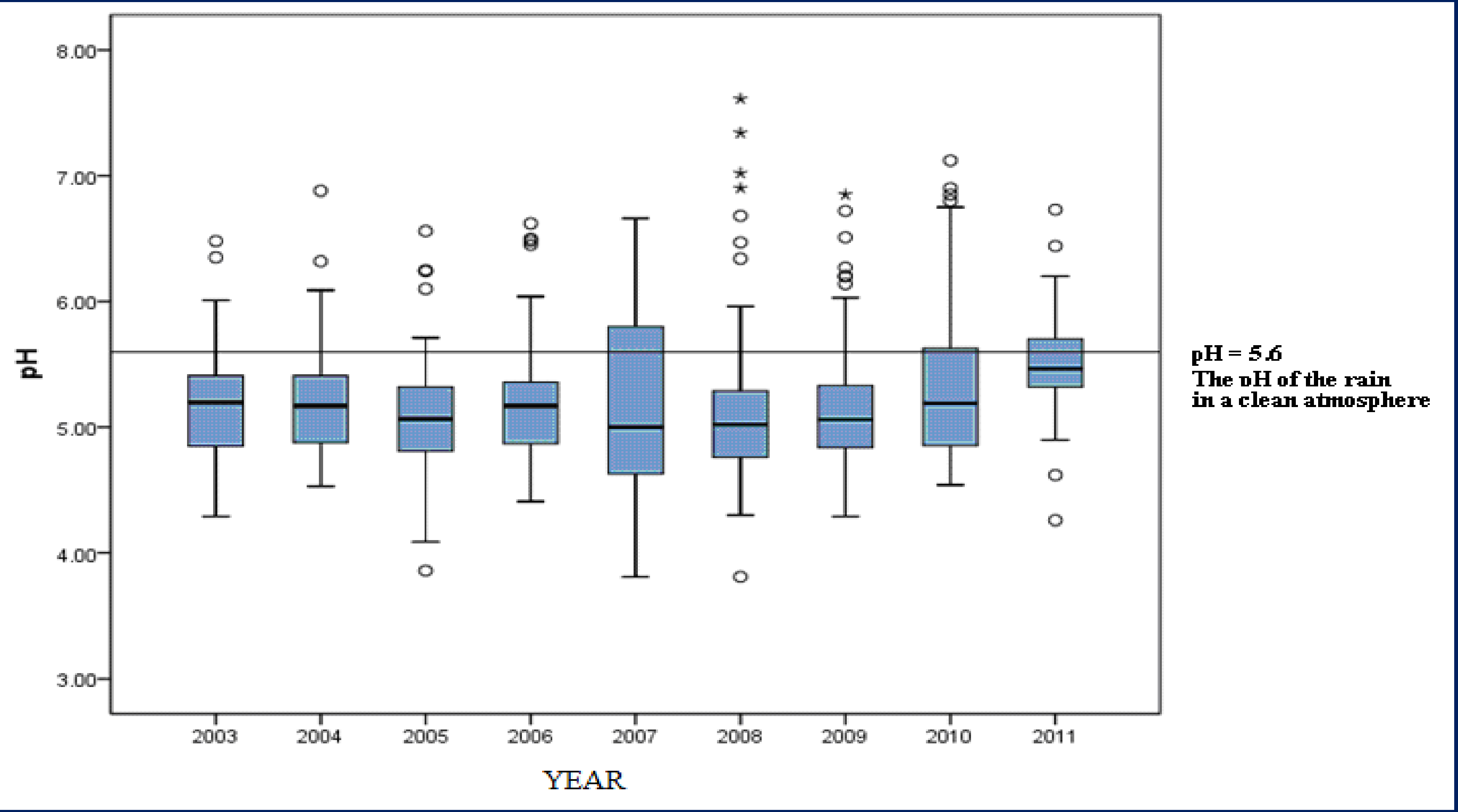

Figure 3. Volume Weighted Mean pH values at La Mancha station.

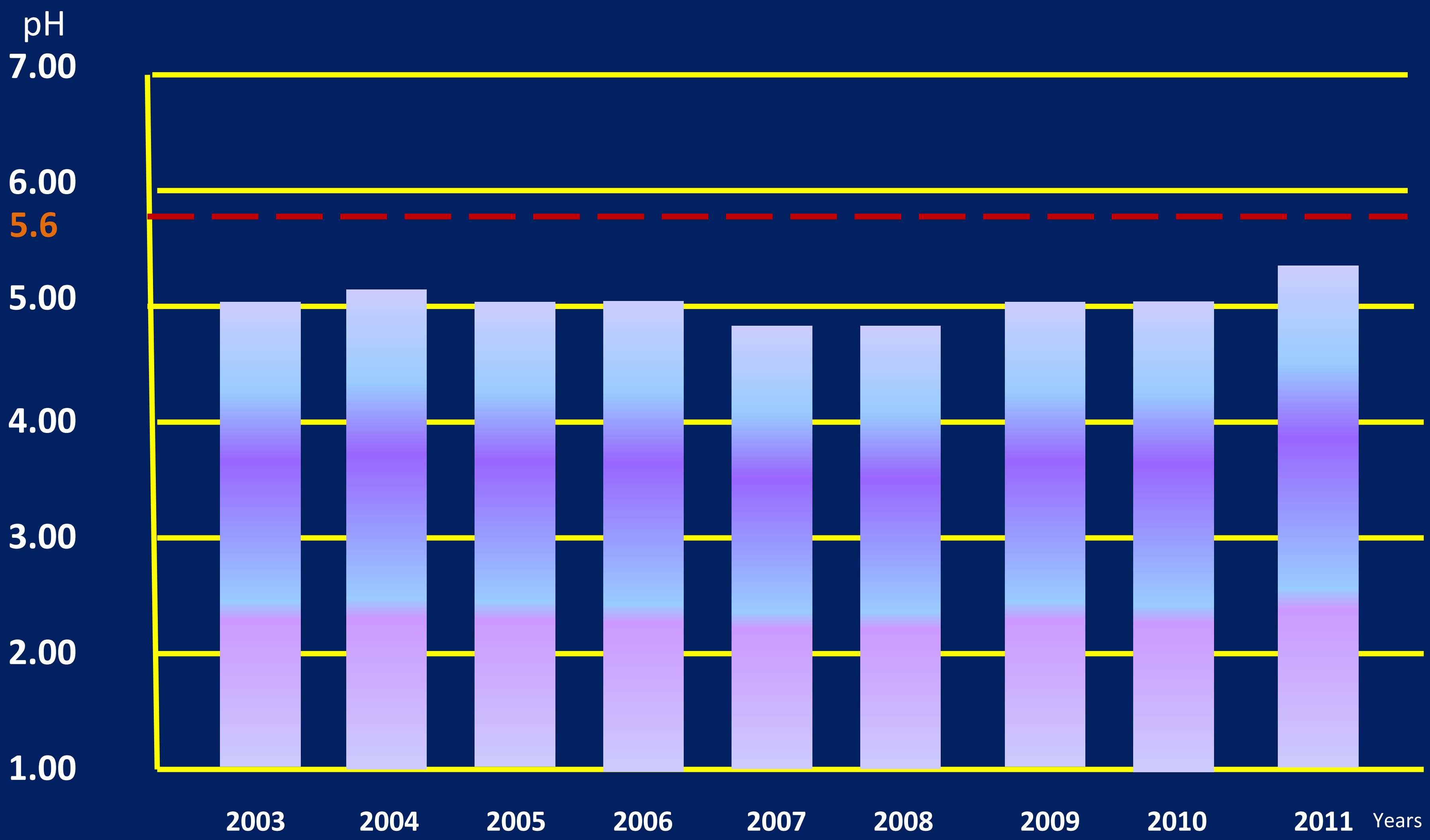

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Figure 4. Volume Weighted Mean ion concentrations at La Mancha station (period 2003-2011).

Figure 5. Monthly percentile 50 for pH at La Mancha station, 2003-2011.

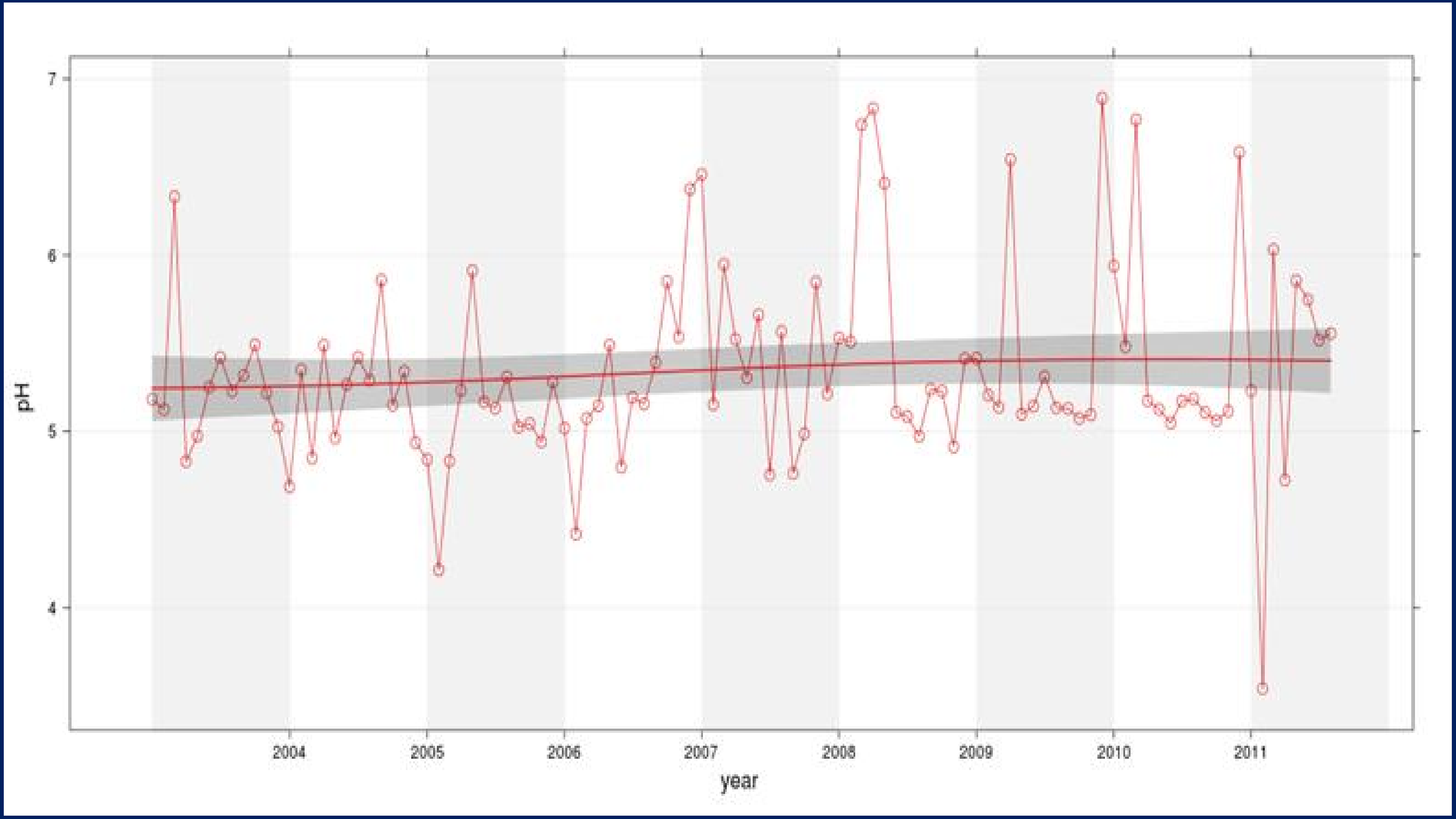

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Figure 6. Monthly mean NO_3^- Deposition at La Mancha station, 2003-2011.

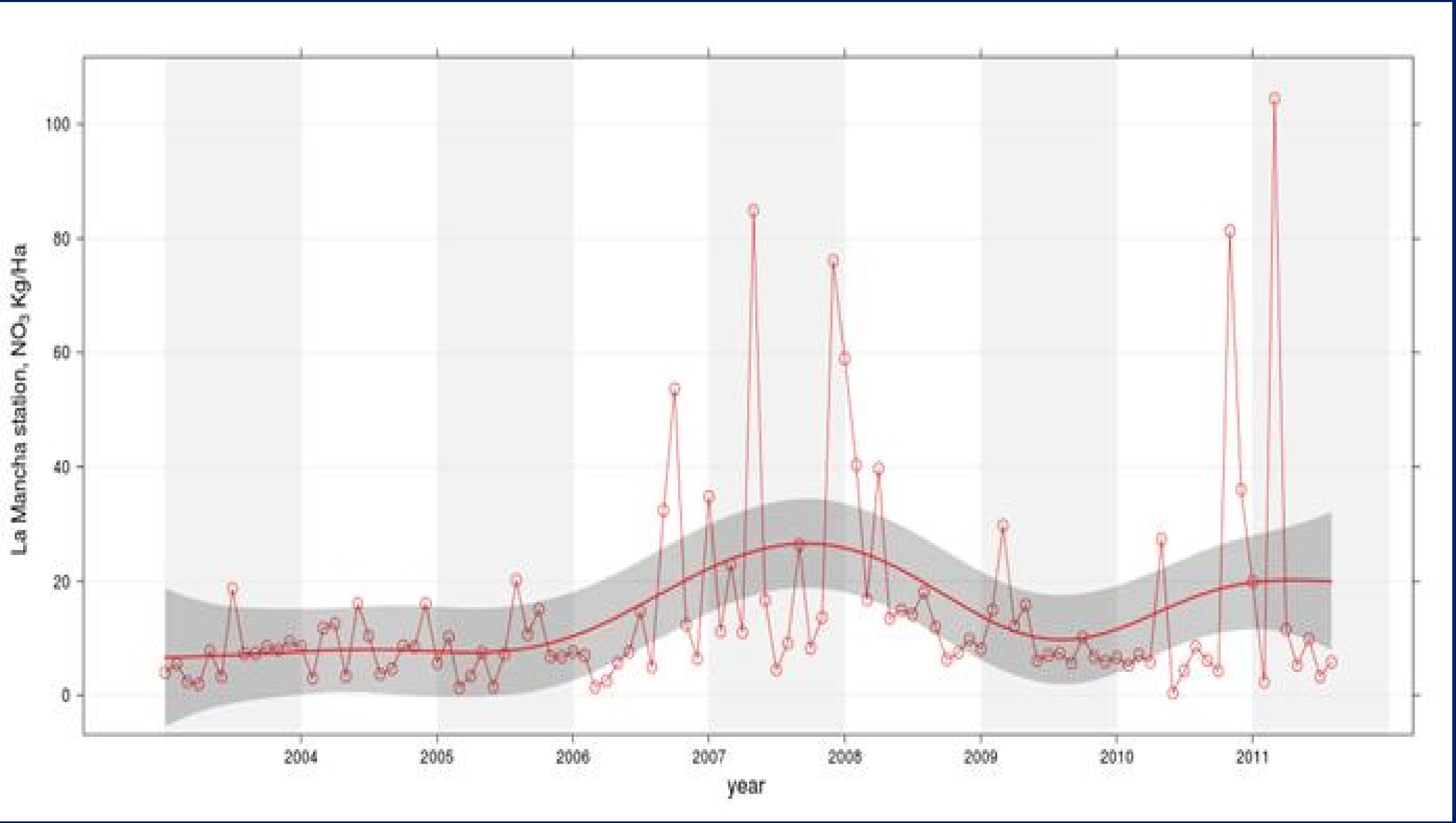

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Figure 7. Monthly mean SO_4^{2-} Deposition at La Mancha station, 2003-2011.

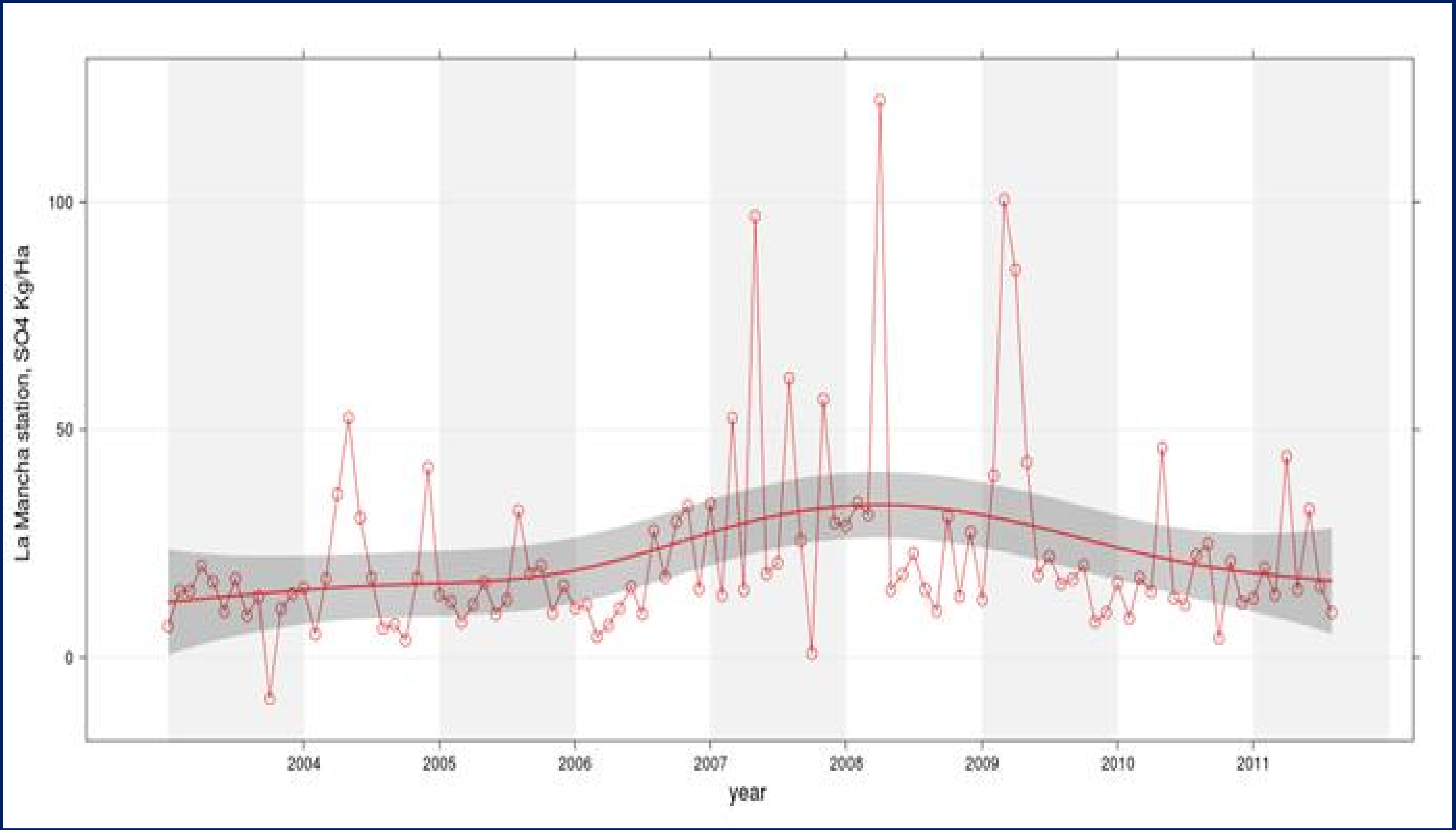

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Table 3. Spearman correlation factor of La Mancha for the period 2003-2011.

	H^+	Na^+	NH_4^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	NO_3^-	SO_4^{2-}	C	pp
H^+	1.000	0.265	0.388	0.348	0.388	0.334	0.278	0.438	0.430	-0.265	0.780
Na^+		1.000	0.497	0.499	0.717	0.595	0.665	0.549	0.563	0.120	0.487
NH_4^+			1.000	0.593	0.525	0.634	0.447	0.667	0.528	-0.010	0.566
K^+				1.000	0.599	0.746	0.489	0.526	0.504	0.036	0.531
Mg^{2+}					1.000	0.675	0.546	0.529	0.525	0.084	0.571
Ca^{2+}						1.000	0.570	0.611	0.612	0.107	0.537
Cl^-							1.000	0.578	0.656	0.151	0.444
NO_3^-								1.000	0.648	-0.018	0.585
SO_4^{2-}									1.000	0.108	0.539
C										1.000	-0.430
pp											1.000

CONCLUSIONS AND RECOMMENDATIONS

Volume Weighted Mean pH values (pH= 4.99) registered at La Mancha atmospheric deposition sampling station from 2003 to 2011, showed clearly the presence of the acid rain phenomena.

The results of the weighted values mean of pH indicated, that wet deposition collected at La Mancha during the period 2003-2011 was acidic. In the statistical analysis of consecutive years of pH at this site, did not show significant variations over a period of nine years of study.

Sulfate ion concentration was higher than the concentration of nitrate ion, suggesting that the formation of acid rain was mainly to the formation and transport of sulfur dioxide in the region of La Mancha.

Sulfates and nitrates presented similar correlation with hydroniun ion (0.43) indicating the participation of both anions in the sulphuric and nitric acids formation, respectively.

Trend nitrate ion concentration did not show a significant variation in nine consecutive years, however, applying the same statistical method, ion concentration of sulfate showed a steady increase from 2003 to 2008.

Cl^- and Na^+ the highest concentration were determinate in 2007. The trends observed are similar for both cations, also showed high correlation ($\rho_{spearman}$ = 0.765) suggesting the same origin or source: the sea.

The ionic balance resulted in a deficiency of anions. This represents a topic for further research. The missing anions could be basically bicarbonates, oxalates, and others.

It is recommended to include the study of the atmospheric dry deposition to complement the study of atmospheric deposition in the study region in a comprehensive manner.

It is recommended that other elements such as aluminum, vanadium, nickel, and manganese to be quantified. This can provide more markers to aid in the identification of potential sources of atmospheric pollutants that can affect the study area.

It is also necessary to consider meteorological parameters and use back trajectories models (eg. US-NOAA–HySPLIT Model) to assess the possible regions of precursor’s emission sources of acid rain.

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THANK YOU

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