

## GLOBAL CHANGE TEACHER INSTITUTE INVESTIGATION

### Acid Deposition Distribution in La Paz and Surroundings

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#### Introduction

The city of La Paz, Mexico, is located in the east coast of the Peninsula of California. From April till October a daily alternate sea-land breeze pattern takes place and from November till March the wind blows mainly from the Northwest.

The “Punta Prieta” electric power plant, which burns diesel, is also located by the seaside at 9 km north of La Paz. The emissions coming out from the smokestack are influenced by the meteorological conditions and when the wind is blowing, they are dispersed downwind.

Because of its geographical isolation and as an additional benefit, the state of Baja California Sur has authorization to import used cars from the United States, which are cheaper than the ones that can be bought in the state. These cars in many cases are old and not in good conditions, so they pollute the air in a considerable way. In addition, the number of cars in the city of La Paz compared to other cities of Mexico is very high, around one car per three persons.

Acid deposition may be on the form of acid rain or dry deposition. La Paz has a dry climate and the main rainfall season is from August till October, so the local problem is considered to be more from acid deposition than from acid rain.

#### PROJECT DESIGN

##### Question:

How and to what extent is the city of La Paz and its surroundings affected by the acid deposition caused by the pollutant emissions from the cars and the electric power plant located north of La Paz? Regarding dry deposition, are there any differences between a rainy month and a dry month?

##### Hypothesis:

The pollutants emitted by the power plant north of La Paz are dispersed in the atmosphere by the prevailing winds, so the highest concentrations of acid deposition will be found mainly downwind. The highest concentrations of acid deposition caused by the pollutants emitted by cars will be found in the areas with more traffic in the city. Dry deposition will be higher in dry months than in rainy months.

##### Study design to test hypothesis:

- Basic knowledge will be given to students regarding the following topics: Air pollutants, Acid deposition, Atmospheric circulation, Contour line drawing, Physical and meteorological factors affecting pollution, and Upper-air diagrams and Chimney plume dispersion.
- Students will gather wind and precipitation data.

- Students will measure pH from dry deposition samples taken at different points in La Paz and its surroundings.
- Students will draw pH isolines on a map.
- Students will determine the areas of higher pH concentrations and relate these values with physical factors, meteorological data, and chimney plume dispersion.
- Students will compare the pH concentration of two different months in the year: a dry month and a rainy month.
- Students will draw conclusions about dry deposition in La Paz and its surroundings.

### Lesson Objectives

Students will:

1. Learn about air pollutants, their sources and effects.
2. Distinguish between wet deposition and dry deposition and how they are monitored.
3. Relate physical and meteorological factors to pH sample-values.
4. Draw isolines on a map.
5. Interpret upper-air diagrams in relation with chimney plume dispersion.
6. Determine the spatial extent of pollution impact in different months of the year.

### Lesson Plan

Lessons	
1	Air pollutants (primary and secondary), their sources and general effects
2	Acid deposition (i.e. acid rain and dry deposition)
3	Atmospheric circulation in La Paz (prevailing winds and sea-land breezes).
4	Precipitation patterns in La Paz.
5	Drawing isolines on a map (i.e. general rules and practice).
6	Factors affecting the pollution concentration and dispersion (i.e. physical and geographical).
7	Meteorological conditions that determine the dispersion patterns of a chimney plume (upper-air diagrams analysis).

### SOURCES

Existing knowledge:

1. Acid deposition and pollution:

Acid Deposition (Adopted by AMS Council on 11 September 2003)

[http://www.ametsoc.org/policy/aciddpo\\_2003.html](http://www.ametsoc.org/policy/aciddpo_2003.html)

EPA Acid Rain and Deposition

<http://www.epa.gov/acidrain/ph.html>

<http://www.epa.gov/castnet/deposition.html>

National Atmospheric Deposition Program. Instruction Manual. NADP/NTN Site Selection and Installation. D.S. Bigelow, Colorado State University, 1984

<http://nadp.sws.uiuc.edu/lib/manuals/siteinst.pdf>

Acid Rain

[http://www.hubbardbrook.org/hbrf/publications/Acid\\_Rain\\_Revisited.pdf](http://www.hubbardbrook.org/hbrf/publications/Acid_Rain_Revisited.pdf)

Air pollution and Chimney plume dispersion

<http://apollo.lsc.vsc.edu/classes/met130/notes/chapter17/index.html>

## 2. Contour lines

<http://mapmaker.meteor.wisc.edu/~jbrunner/ackerman/contourl/isothermbkgrnd.html>

## 3. Real time upper-air data and information on Skew-T diagrams:

<http://www.rap.ucar.edu/weather/upper/>

<http://weather.uwyo.edu/upperair/sounding.html>

[http://weather.unisys.com/upper\\_air/skew/details.html](http://weather.unisys.com/upper_air/skew/details.html)

<http://smn.cna.gob.mx>

## 4. Meteorological data:

Wind roses: Weather station in La Paz

Precipitation data: <http://smn.cna.gob.mx>

## 5. Dr. Andrew J. Burton

Direct Communication on how to measure dry deposition.

## **DATA COLLECTION**

### **Materials**

1. Dry deposition samples taken from different points in La Paz and surroundings for two different months: May (dry) and September (rainy).
2. Two maps (May and September) of La Paz and its surroundings with sample-location points. The sample points were chosen in a radial form (N, NE, E, SE, S, SW, W and NW) and at different distances: 5, 10, 20 and 30 km from the "Punta Prieta" power plant.
3. Two Tables (May and September) with pH values of dry deposition from different points located in La Paz and its surroundings.
4. Monthly wind and precipitation data from the weather station at La Paz.
5. Chimney plume dispersion and Upper-air diagrams (Skew-T) of La Paz, showing different meteorological conditions.

## **DATA ANALYSIS AND CONCLUSIONS**

1. Students will measure the pH from the samples taken at different points of a given month (dry or rainy).
2. Students will plot on Map 1 the values of the pH samples given to them and they will draw isolines of pH values. Map 2 will already have the pH values and respective isolines.
3. Students will fill Table 1 with the following sample information: pH values, direction and distance from the power plant; and geographical information.

4. Students will compare the pH values distribution on their map with the physical and geographical factors affecting the area, and the meteorological data (wind, rain, and upper-air diagrams).
5. Students will be given Table 2 with data already filled, and they will compare their work done on Table 1.
6. Students will draw relevant conclusions regarding dry deposition in La Paz as an important aspect of global change.

## **EXTENSIONS**

### **1. Plans for long-term data gathering:**

Dry deposition will be monitored each month so that future data may be compared with the previous one.

### **2. Samples in the city of La Paz:**

More samples from dry deposition within the city of La Paz will be taken so that students will be able to determine areas of higher and lower concentrations in relation to traffic areas.

Name: \_\_\_\_\_

**Activity: Acid Deposition Distribution in La Paz and its Surroundings**  
Student Response sheet

**Time:** 3 hours

**Question:**

How and to what extent is the city of La Paz and its surroundings affected by the acid deposition caused by the pollutant emissions from the cars and the electric power plant located north of La Paz? Is there any difference between a rainy month and a dry month?

**Hypothesis:**

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**Materials:**

1. Dry deposition samples taken from different points in La Paz and its surroundings during the month of May (dry month).
2. pH meter.
3. Two Tables (May and September) with pH values of dry deposition from different points located in La Paz and its surroundings.
4. Two maps (May and September) of La Paz and its surroundings. The one of May only with sample-location points and the one of September with pH values and isolines.
5. Monthly wind and precipitation data from the weather station at La Paz.
6. Chimney plume dispersion and Upper-air diagrams (Skew-T) of La Paz, showing different meteorological conditions.

## 1. pH Values

Table 1. pH samples

Month: May Year: \_\_\_\_\_

Sample	Direction from power plant	Distance from power plant	Dry deposition pH	Physical or geographical factors (seaside, mountain –windward or leese, urban, rural...)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

Table 2. pH samples

Month: September Year: \_\_\_\_\_

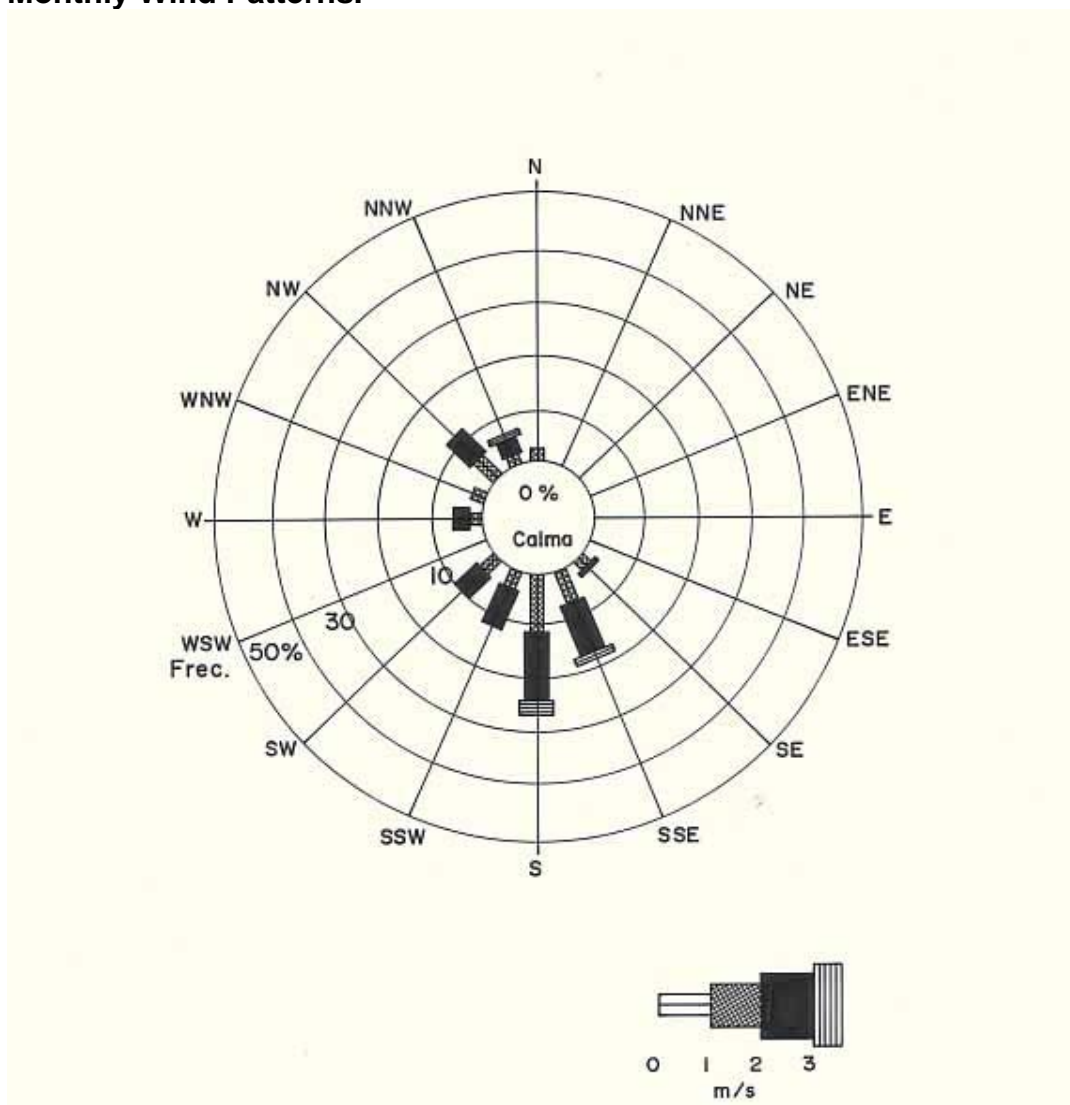
## 2. Maps of La Paz

This map shows La Paz and its surroundings and the location points where the dry deposition samples were taken.

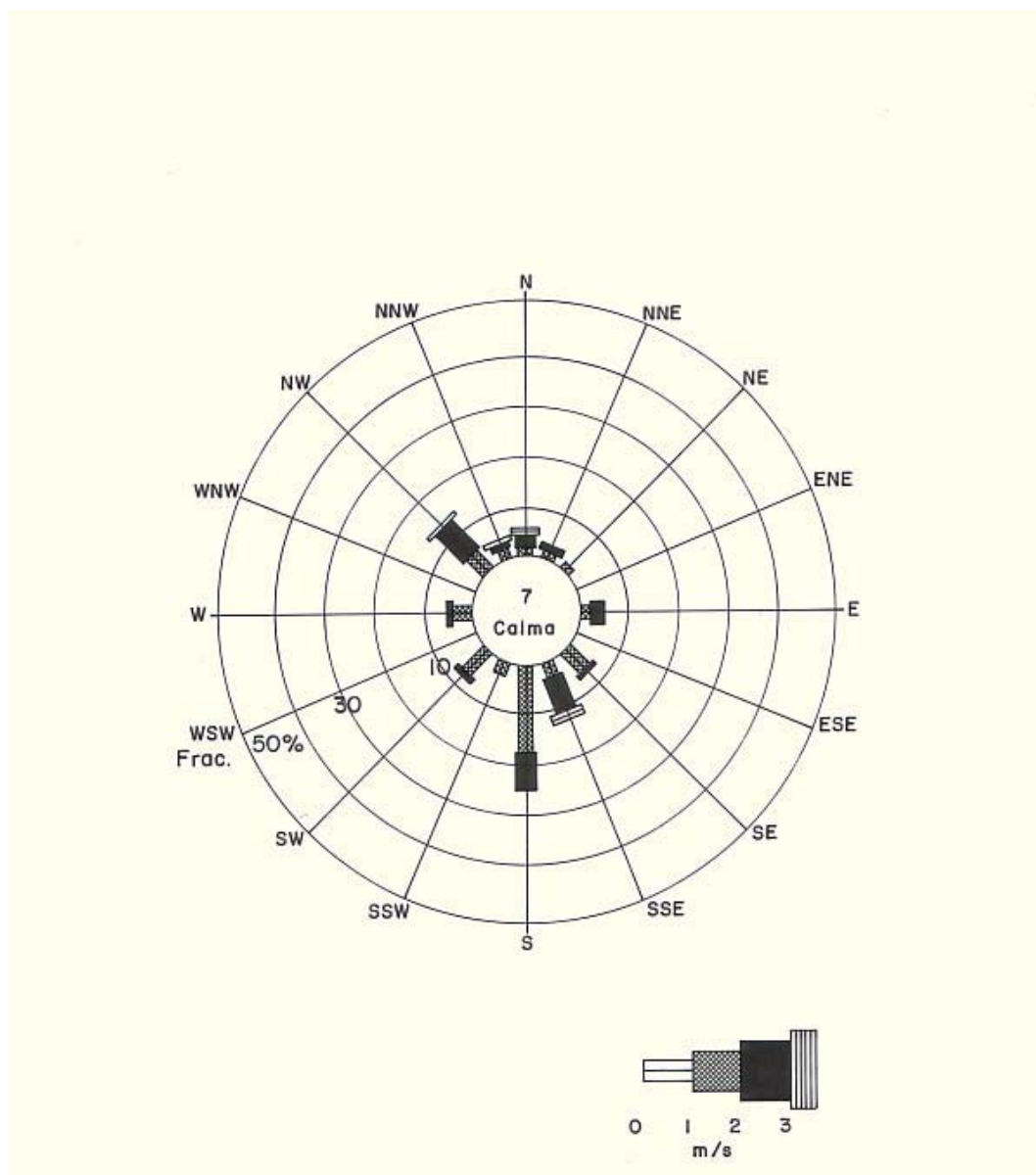
Map 1. May  
Map 2. September



### 3. Monthly Wind Patterns.



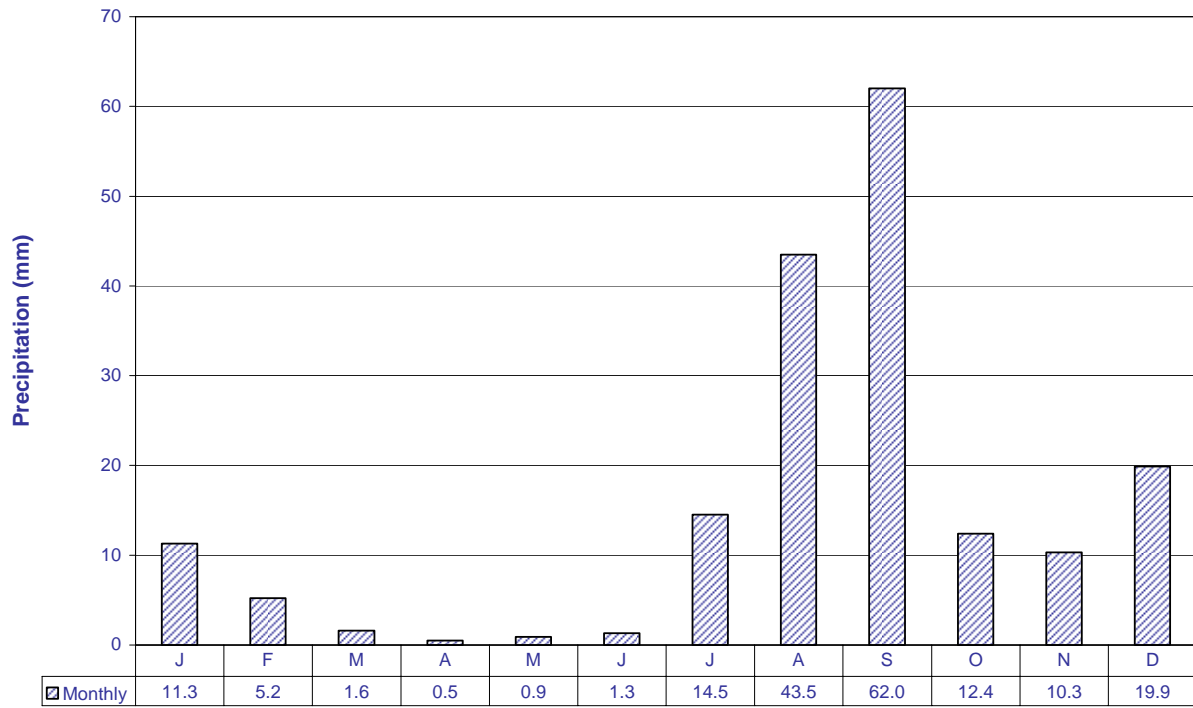
**Figure 1. Wind Rose from La Paz, month of May**  
Source: La Paz Weather Station



**Figure 2. Wind Rose from La Paz, month of September**  
Source: La Paz Weather Station

#### 4. Monthly Precipitation Graph

Monthly Precipitation. La Paz, BCS  
(1921-2005)



Source: <http://smn.cna.gob.mx>

## 5. Chimney Plume Dispersion

Figure 3.

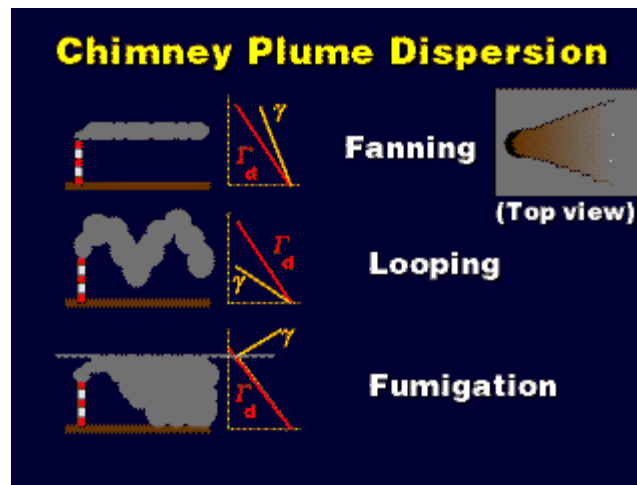
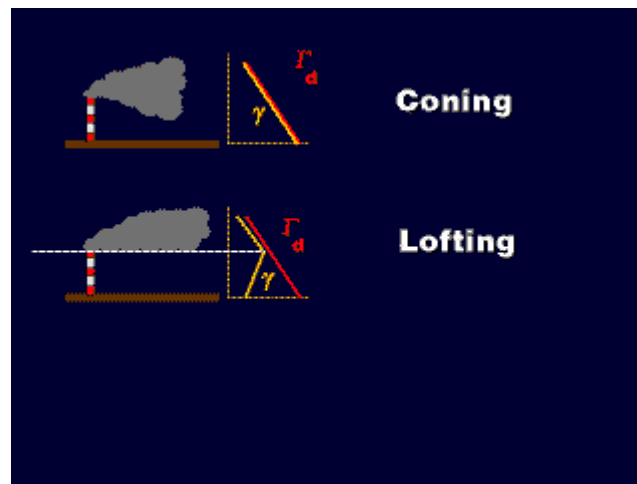


Figure 4.



Source: <http://apollo.lsc.vsc.edu/classes/met130/notes/chapter17/index.html>

**PROCEDURE:**

- Students will be divided in small groups:
  1. Each group will measure the pH of one sample taken during May and will share their results with all the other students.
  
- For each student:
  2. Table 1, fill the pH values of the different samples.
  3. Map 1, calculate the direction and distance of the different sample locations and fill the answers on Table 1.
  4. Map 1, plot the pH values from the samples given on Table 1.
  5. Map 1, draw the pH isolines.
  6. Analyze this map and describe on Table 1 the physical or geographical factors affecting each sample location-point.
  
- Answer the following questions:
  7. Analyze the wind roses from La Paz (Figures 1 and 2).
    - a) From which directions does mainly the wind blow on May? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
    - b) During May, on which directions would you expect to have (if any) higher concentrations of dry deposition? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
    - c) From which directions does mainly the wind blow on September? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
    - d) During September, on which directions would you expect to have (if any) higher concentrations of dry deposition? \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
  
  8. Analyze the monthly historical precipitation data from La Paz.
    - e) Which is the month that receives more rain? \_\_\_\_\_ Compared to the annual precipitation, what is the rainfall percentage for this month? \_\_\_\_\_
    - f) Is May a rainy month? \_\_\_\_\_ Compared to the annual precipitation, what is the rainfall percentage for this month? \_\_\_\_\_
    - g) On which of these two months would you expect to have more dry deposition? \_\_\_\_\_
  
  9. Analyze the pH values from Maps 1 and 2.
    - h) Are your answers on questions 7 and 8 consistent with the results shown on both maps? \_\_\_\_\_ Explain yourself \_\_\_\_\_  
 \_\_\_\_\_

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10. Analyze the different patterns of chimney plume dispersion (Figure 3 and 4), and answer the following questions.

a. During clear nights and light breezes, the air in La Paz is usually stable and the plume disperses at a right angle downstream (fanning plume). Would you expect to have high pollution concentrations and dry deposition at the ground? \_\_\_\_\_

b. During clear evenings when an inversion near the surface occurs with unstable air above it, the plume will dilute upward (lofting plume). Comparing the lofting plume with the fanning plume, which one would you expect to produce much lower pollution concentrations at the ground at a distance downstream? \_\_\_\_\_

c. During summers and day time, the air in La Paz is usually unstable, so the plume whips up and down (looping plume) as the atmosphere mixes around, with high pollution concentrations reaching the ground. Would these last for long periods of time? \_\_\_\_\_

d. During hot summer days in La Paz, when an inversion aloft occurs this will trap the pollutants underneath it (fumigation plume), preventing a vertical dispersion. Would you expect to have low or high pollution concentrations at the ground? \_\_\_\_\_ Would these last long periods of time? \_\_\_\_\_

e. When there is a neutral atmosphere in La Paz, the plume spreads equally in the vertical and horizontal as it propagates downstream (coning plume). Where would you expect the pollution concentrations to reach the ground, close to the smokestack or far away? \_\_\_\_\_

f. All these meteorological conditions that take place in La Paz depend, among other factors, on the time of the day or the season of the year. What would you expect regarding the distribution of dry deposition in La Paz and its surroundings? \_\_\_\_\_

8. Conclusions.

a) Do you consider dry deposition to be a problem in La Paz? \_\_\_\_\_  
Explain your answer \_\_\_\_\_

b) What measures could be taken to reduce dry deposition and its effects? \_\_\_\_\_