Searching for Nature Stories (Learning and Practising Nature Exploration)

Effects of air pollution on the distribution of lichens in different regions of Kwai Chung

School: Pope Paul VI College (Group 29)

Members: Chan Cheuk Lam Chung Ming Yan,
Tam Kam Fung Tang Hoi Ki

Adviser: Miss LEE Lai Ping Goretti

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1. Abstract

Lichens are used as a biological indicator of air pollution. In 1979, a joint school project, “Clean Air and Lichen project, 1979”, showed that Kwai Chung was a lichen desert. We would like to find out if the problem of air pollution in Kwai Chung has lessened now or not.

2. Biological principles and purpose of this investigation

What are lichens?

Lichens are examples of mutualism, a type of symbiosis. They are close association between fungi and algae or green algae, their photosynthetic partners. The dominant partner in this kind of mutualistic association is a fungus. In this partnership, the fungus is called the ‘mycobiont’ and the one or more algae and /or of cyanobacteria is / are called the ‘photobiont’.

Fungi are incapable of making their own food. They provide stability and support, catch water in the form of rain, moisture (even from unsaturated air), fog; as well as minerals dissolved in water, so as to prevent algae from drying out. The lichen fungi (kingdom Fungi) cultivate their partners that manufacture food by photosynthesis. But the fungus are dependent on its algal partner for organic food. The photobiont possess the green pigment chlorophyll, enabling them to use sunlight energy to make their own food from water and carbon dioxide through photosynthesis. Most of the photobiont is usually either green alga or cyanobacterium, formerly called blue-green algae. A few lichens are known to contain yellow-green algae or, in one case, a brown alga. In all cases, the appearance of the fungus in the lichen is quite different from its morphology as a individual. The body of a lichen consists of fungal filaments (hyphae) surrounding cells of green algae and/or blue-green cyanobacteria.

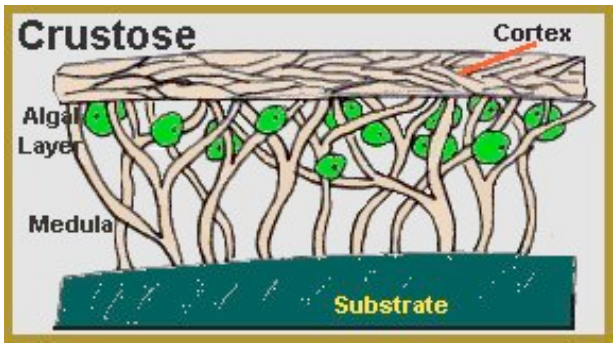

Fig 2.1 the structure of crustose

What are the environmental factors affecting the growth of lichens?

Lichens will and do grow on just about everything, natural or manmade. Lichens survive in an extremely wide range of temperatures. They have been known to survive

temperatures as low as -190C for several hours and as low as -78C for several days. Going to the other extreme they can also survive temperatures as high as 100C if they are dried out, and even when moist temperatures of 40-50C do not worry them. However because they depend on their Algal partners to photosynthesise in order to obtain energy for growth, all lichens need light. There are therefore no subterranean or deep cave dwelling lichens. Generally speaking lichens like areas where there are plenty of light, such as the exposed surfaces of alpine rocks, and the roofs of our houses etc. Lichens have the ability to quickly absorb and retain water from many sources. They can absorb moisture from dew or fog, even from the air itself if the humidity is very high and the temperature is low. They also dry out slowly, making it possible for the photosynthesizing partner(s) to make food for as long as possible. Thus,water availability is not an important environmental factor affecting the growth of lichens .This makes them possible to live in a large variety of environments like deserts and polar regions, and on exposed surfaces like bare rocks, roofs and tree branches. They also have a high tolerance for radioactivity and can be the first organisms to colonise, or the longest to survive in areas of high radioactive contamination. However, many lichens show varying degrees of sensitivity to man-made pollutants.

How does sulphur dioxide affect the growth of lichens?

Lichens are very sensitive to sulphur dioxide because their efficient absorption systems result in rapid accumulation of sulphur when exposed to high levels of sulphur dioxide pollution. The algal partner seems to be most affected by the sulphur dioxide, chlorophyll is destroyed and photosynthesis is inhibited.

What is biological indicator of air pollution?

In natural habitat, the kinds of organisms present are often determined by specific factors. Some organisms can survive in highly polluted environment while some others are extremely sensitive to pollutants. Thus it is sometimes possible to judge the degree of pollution of an environment from the specific organisms present. These specific organisms are called biological indicators.

Why lichens can be used as indicator of air pollution?

Lichens are widely used as environmental indicators or bio-indicators. If air is very badly polluted with sulphur dioxide, there may be no lichens present, just green algae may be found. If the air is clean, shrubby, hairy and leafy lichens become abundant. A few lichen species can tolerate quite high levels of pollution and are commonly found on pavements, walls and tree bark in urban areas. A lichen zone pattern may be observed in large towns and cities or around industrial complexes which corresponds to the mean levels of sulphur dioxide experienced.

What are the sources of surplur dioxide in air?

Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide.Common sources of sulphur dioxide include smelting, burning of fossil fuels, manufacture of sulphuric acid, paper making, incineration of rubbish and production of elemental sulphur. Coal burning is the largest man-made source of sulphur dioxide accounting for about 50% of annual global emissions, with oil burning accounting for a further 25-30%. The most common natural source of sulphur dioxide is volcanoes.

Our concern about the air pollution level in Kwai Chung:

In 1979, many schools in Hong Kong made sets of comparative measurements in different areas around their schools and were able to pin-point areas with the highest pollution from particulates. The project is “Clean Air and Lichen project,1979”. It was found that Kwai Chung was a lichen desert, which means there were no lichens on any trees, only a green film of the alga Protococcus, with sulphur dioxide level over 200 g/m³ air for much of the time and a mean pH value of rain of 4.50. We are interested in finding out whether there has been any change in the level of air pollution in Kwai Chung since 1979. Also, we would like to know how serious can air pollution affect the growth of lichens.

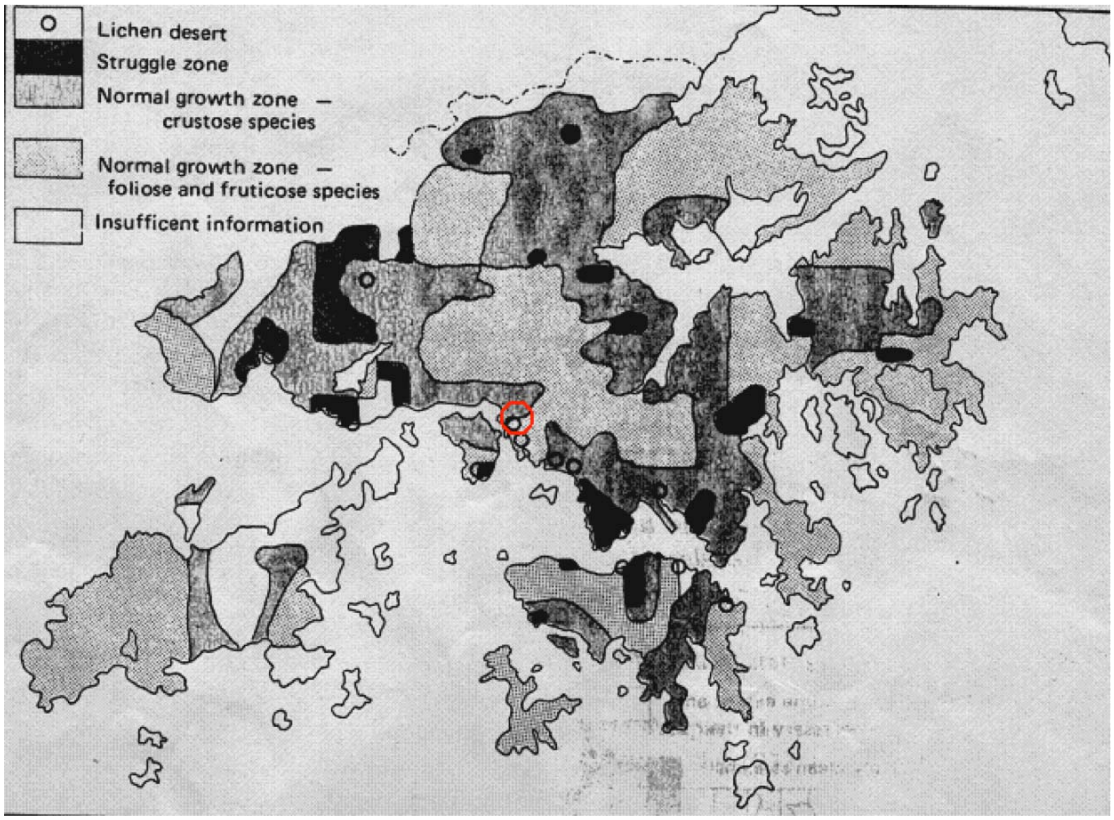

Fig 2.2: The result of “Clean Air and Lichen project, 1979” showing that Kwai Chung was a “lichen desert”

3. Objective

How air pollution affects the distribution of lichens in different region of Kwai Chung

3.1 Hypothesis and prediction of results

The types and abundance of lichens should be found in less polluted area such as the country park, where the air quality is less affected by human activities.

4 .Method

4.1 Outline of the investigation design

Our investigation was carried out at three different spots in Kwai Chung: the country side (Golden Hill),the residential area (Shek Lei Estate) and the industrial area in Kwai Chung(Wo Yi Hop Road). These represent different level of air pollution: low(vehicles flow rate:0 car per 5mins.) , medium(vehicles flow rate:53 cars per 5mins.) and serious(vehicles flow rate:85 cars per 5mins.) respectively. At each spot, fifteen tree trunks were investigated. The number of species and size of lichens on the surface of the lower part of the tree trunks were studied to test our hypothesis.

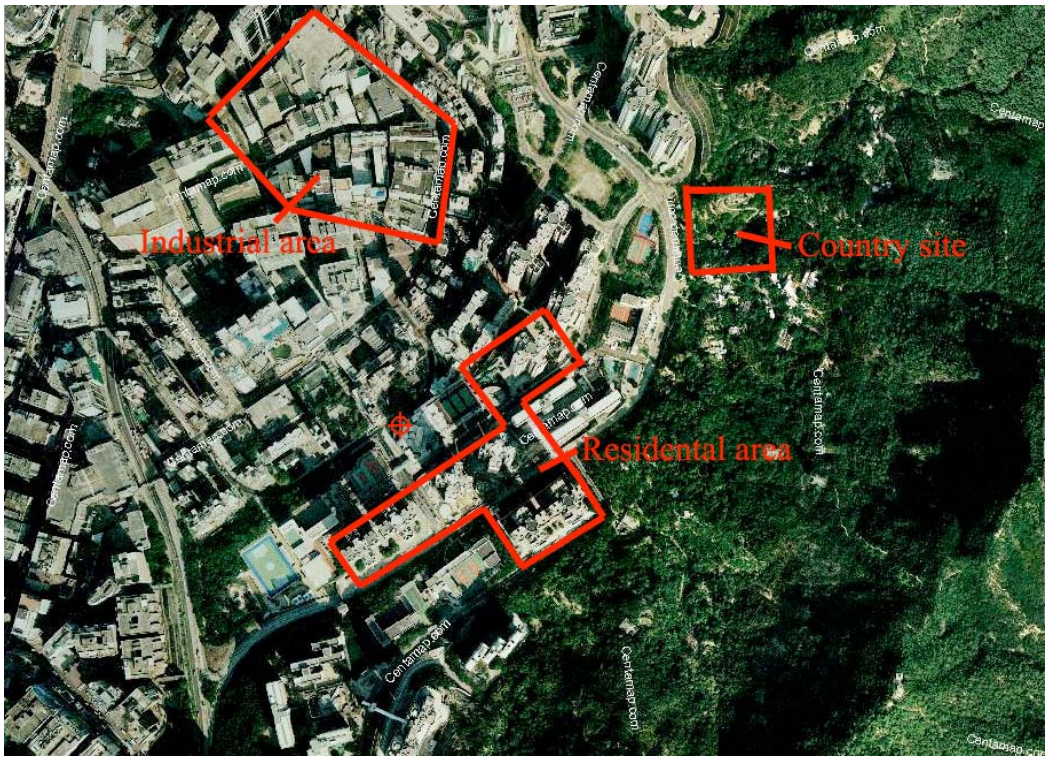

Fig 4.1.1 Map of Kwai Chung

Fig.4.1.2 Country park (Golden Hill)

Fig. 4.1.3 Residential area (Shek Lei Estate)

Fig. 4.1.4 Industrial area (Wo Yi Hop Road)

The independent variable was the degree of air pollution indicated by flow rate of motor vehicles running along the road per minute. The dependent variables were the number of lichen species and their relative abundance in terms of percentage coverage in the quadrat. The control variables of our investigation were temperature, sunlight (direction and degree of shading) and humidity. Data collection was carried out at different sites on the same day to control the temperature and relative humidity.

4.2 Apparatus and materials

- Compass (x2)
- Measuring tape (x1)
- Ruler (x1)
- Transparent Quadrats (15cm x 15cm)(x2)

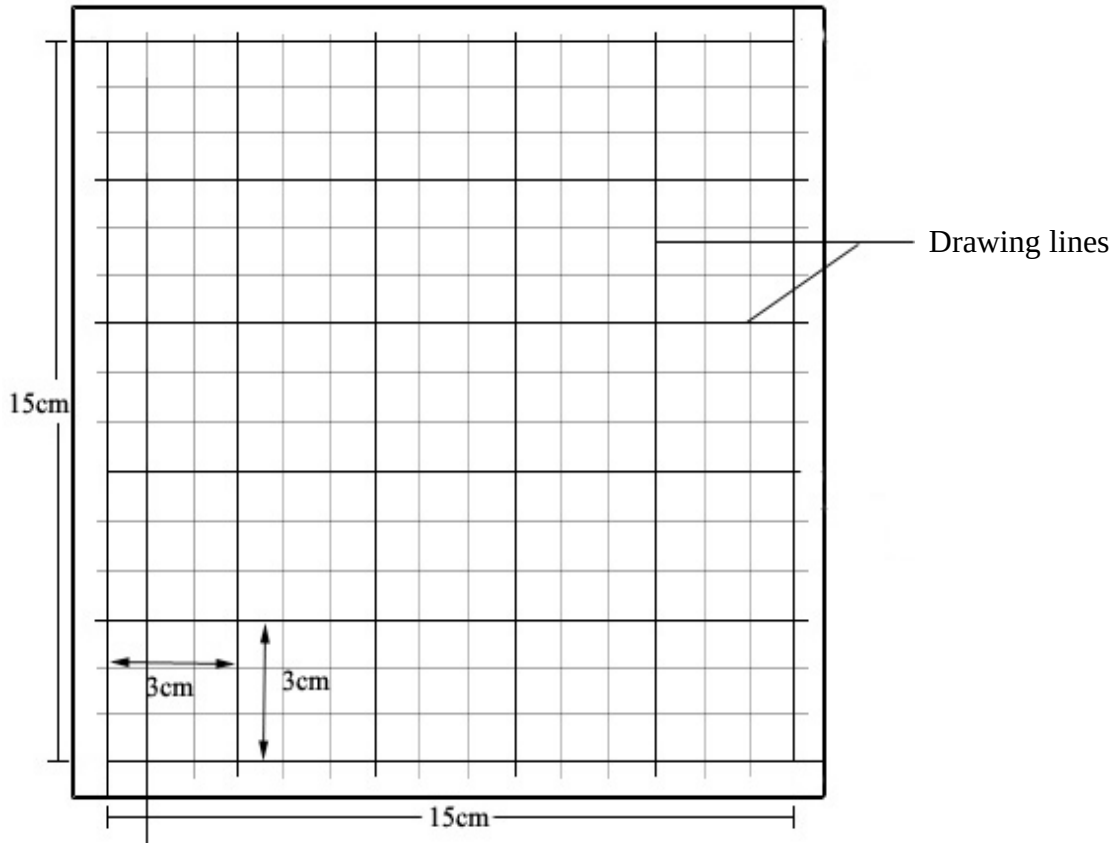

Fig. 4.2.1 transparent quadrat frame (15cmx15cm) with line subquatrats (each 3cm x 3cm)

4.3 Procedure

1. In each study site, an open area was chosen for collecting data. This could ensure that the degrees of shading/light intensities of the study sites were similar.

2. The circumference of the tree for studying was measured at it's height of 1.5m . Only if its circumference was between 50cm-60cm, was a sample for studying. This was to control the size of the tree samples being similar suitable for using the quadrat to study the percentage coverage of lichens.

3. Based on the above criteria, 15 tree samples were chosen in each site at random.
4. A compass was used to choose the eastern face of each tree for investigation. This was to control the direction of sunlight and the light intensity of all the tree samples.
5. At the height of 1m of each tree, the nearest lichen zone was found and the transparent quadrat was laid on it. The number of species were identified and counted and the percentage coverage was measured.
6. The number of motor vehicles running along the road in each region was counted and the flow rate of motor vehicles min^{-1} was calculated

Fig. 4.3.1 Using a compass to locate the east face of the tree and a ruler to measure the height of 1 m.

Fig. 4.3.2 laying the transparent quadrat on the lichen zone

Fig. 4.3.3 using a measuring tape to measure the circumference of the tree

5. Results

Site 1: Golden Hill

Date: 9thMarch, 2008

Land use: Country Park, open area

Weather: sunny

Temperature: 18C

Relative humidity: 69%

Table5.1 Lichens percentage coverage of Golden Hill study site

Tree no. / Quatrats	Fully covered	1/2 covered	≤1/4 covered	Total percentage coverage
1	225	24	4	79%
2	51	6	4	19%
3	119	18	20	44%
4	71	6	21	26%
5	60	15	10	24%
6	227	9	7	78%
7	142	9	14	50%
8	82	10	15	30%
9	96	6	10	34%
10	103	8	12	37%
11	119	18	15	44%
12	88	15	18	33%
13	218	12	9	75%
14	101	18	7	37%
15	176	9	12	61%

Average: 44.7%

Site 2:Shek Lei Estate

Date: 9thMarch, 2008

Land use: residential area, open area

Weather: sunny

Temperature:18C

Relative humidity:69%

Table 5.2 Lichens percentage coverage of Shek Lei Estate study site

Tree no. / Quatrats	Fully covered	1/2 covered	≤1/4 covered	Total percentage coverage
1	0	0	0	0%
2	1	1	0	0.5%
3	0	0	0	0%

Tree no. / Quatrats	Fully covered	1/2 covered	≤1/4 covered	Total percentage coverage
4	9	2	1	3.4%
5	0	0	0	0%
6	2	0	9	1.4%
7	12	2	0	4.3%
8	0	0	0	0%
9	3	1	10	2%
10	9	15	3	5.3%
11	11	9	3	5.4%
12	4	8	0	2.7%
13	0	0	0	0%
14	5	9	2	3.3%
15	2	0	4	1%
			Average:	2%

Site 3:Wo Yi Hop Road

Land use: industrial area

Date: 9thMarch,2008

Weather: sunny

Temperature:18C

Relative humidity:69%

Table 5.3 Lichens percentage coverage of Wo Yi Hop Road study site

Tree no. / Quatrats	Fully covered	1/2 covered	≤1/4 covered	Total percentage coverage
1	0	0	0	0%
2	0	0	0	0%
3	0	0	0	0%
4	0	0	0	0%
5	0	0	0	0%
6	0	0	0	0%
7	0	0	0	0%
8	0	0	0	0%
9	0	0	0	0%
10	0	0	0	0%
11	0	0	0	0%
12	0	0	0	0%
13	0	0	0	0%
14	0	0	0	0%
15	0	0	0	0%

Average: 0%

Table 5.4 Lichen species found in Golden Hill, Shek Lei Estate and Wo Yi Hop Road

Site / Types	Drinaria picta	Chrysothrix candelaris	Lecanorora leprosa	Coccocarpia palmicola
Golden Hill (country park)	✓	✓		✓
Shek Lei Estate (residential area)	✓		✓	✓
Wo Yi Hop Road (industrial area)				

Fig 5.5(a), (b) and (c) showing lichens found in Golden Hill

Fig 5.5 (a)

Fig 5.5(b)

Fig 5.5(c)

Fig. 5.6(a), (b) and (c) showing lichens found in Shek Lei Estate

Fig 5.6(a)

Fig 5.6(b)

Fig 5.6 (c)

Fig5.7 Distribution of lichens in different regions of Kwai Chung

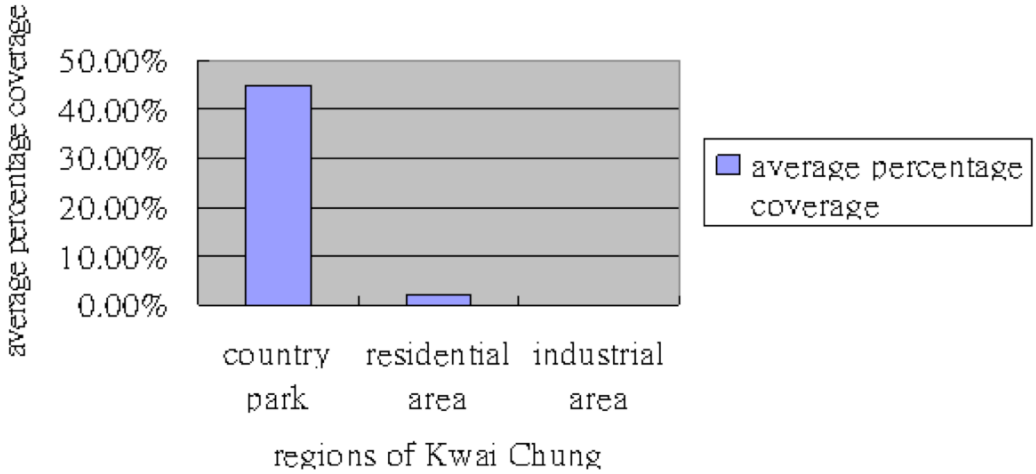

Table 5.8: Flow rate of motor vehicles per minute

Region	Flow rate of motor vehicles min^{-1}
Golden Hill	0
Shek Lei	10.60
Wo Yi Hop Road	17

6. <u>Analysis and conclusion</u>

It was found that both country park and residential area had 3 types of lichens, but no lichens were found in industrial area.(table 5.4) The average percentage coverage of lichens in the country park was the largest, 44.7% (table 5.1 and figure 5.7) , the second was the residential area, 2 %.(table 5.2 and figure 5.7) The country park had the largest average percentage coverage of lichens because it had the lowest flow rate of motor vehicles (0 min^{-1}) (table 5.8) and thus the smallest amount of sulphur dioxide emitted into air.. The residential area had a much smaller average percentage coverage of lichens because it had having much greater flow rate of vehicles (10.6 min^{-1}) (table 5.8) than the country park and a larger amount of sulphur dioxide in air. The industrial area had the greatest flow rate of motor vehicles (17 min^{-1}) (table 5.8). Lichens were not found there (table 5.3 and figure 5.7) because burning of fuels in factories and the heavy traffic there had released much sulphur dioxide in air, which had made the environment unfavorable for the growth of lichens.

There were some unavoidable errors and limitations of the methods in our investigation that may have affected the accuracy and the reliability of our results.

First, there may be reading error in the percentage coverage of lichens in the quadrat. We drew of 1cm x 1cm in the transparent quadrat.The lichens may not occupy the whole grid in some of them. It was not accurate to determine the percentage coverage just by naked eye and impression. Second, there should be some factors other than the sulphur dioxide affecting the growth of lichens, for examples, human activities and light intensity. Thus the results may not show the sole effect of sulphur dioxide. Also, trees of different species were chosen as samples. The texture and other features of the tree bark may affect the growth of lichens as well. For improvement, we suggest the use of smaller grids in the quadrat to measure the percentage of lichen coverage for more accurate reading. Also, trees of same species should be chosen as samples to make the result more reliable.

Conclusion

The country Park has the greatest number of lichen species and abundance. This is because the country park is relatively remote and less polluted with sulphur dioxide, so more lichens can grow there. Both country park and residential area have more types of lichens than industrial area because the level of air pollution in these areas are less serious. No lichens are found in industrial area because the air pollution there is very serious.Despite their absence in industrial area, we still find lichens in the residential area which proved that the air pollution of Kwai Chung has become less serious than 1979.

7. Significance of the findings and suggestions

The experiment proved that the air quality of Kwai Chung has improved since 1979.We believed this is because of the efficacy of the government's regulations and measures regarding control of air pollution. But still, the number of lichen species found in Kwai Chung is comparatively lower than other districts in Hong Kong. We suggest the government to set up more restrictive laws to control the emission of exhaust gases from motor vehicles because it is the major source of sulphur dioxide. . The Environmental Protection Department should monitor the air pollution level in different districts closely and step up necessary actions so as to ensure the regulations are and measures are really efficacious.

8. References

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