ISSN : 0974 - 7435 Volume 10 Issue 8

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(8), 2014 [2369-2374]

# Direct influences on AQI, PM2.5 and PM10 after and before vehicle limit line

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## ABSTRACT

Stored up the study of chemical composition and characteristics on air quality, the paper's preference is the ameliorated influences on set-2 (AQI, PM2.5& PM10) owing to set-1 of the chemical and atmospheric factors. Based on 245 samplings of the official websites, the correlations and effect degrees are primarily analyzed in the 6 different scenarios. CCA technique is proposed and the austerely statistic significance of CCA regression at each scenario is achieved. The findings are that, before and after Vehicle Limit Line, the evidently lowered correlations (set-1 and No2) on weekdays and the obviously raised correlations (set-1 and So2) on weekend are presented, as well as the influences are statistically coincident and synchronously lessened especially from Co on workdays, while hysterical indistinguishableness on workend.

## KEYWORDS

Particulate matter (PM); Air quality index (AQI); Canonical correlation analysis (CCA); Vehicle limit line (VLL).



## INTRODUCTION

Particulate matter (PM) is attracted increasing attention from chemist, environmentalist, meteorologist, urbanologist, anthropologist, and healthy-security expert et al, which develops many disciplines including environmental, aerosol, chemosphere, hazardous, toxicology and physical sciences etc, and brings on some specifics in research fields such as fuel and energy, transportation, earth systems, applied pharmacology, allergy, clinical immunology and building. PM2.5, PM10 and PM2.5-10 are especially concerned about (Cheng et al, 2014; Fortune et al, 2014; Pandolfi et al, 2011; Taiwo et al, 2014; Yang et al, 2014; Zhao et al, 2014)[1-6]. Generally, atmospheric particle with diameter of 2.5 micrometers or less is called PM2.5 or Fine Particulate Matter. And included both fine and dust particles, named respirable suspended particle (RSP) in Wikipedia, PM10 is the particulate less than 10 micrometers in aerodynamic diameter. While PM2.5-10 is the particle with aerodynamic diameter 2.5-10 micrometers, also called coarse particles. What's more, ultrafine particle (PM1.0) and suspended particulate matter (SPM) on Wikipedia or total suspended particulates (TSP) with diameter greater than 10 micrometers are mentioned.

Sources and health effects of air pollution by EPA (2010) list 6 pollutants, and in the paper, the 3 choices are introduced that[7] (i) Oxides of Nitrogen (NOx) sources from vehicles& industrial burning of fossil energy and combustion plants, and leads to lung diseases and battered respiratory infection; (ii) Carbon Monoxide (Co) is especially created by vehicles, which aggravates heart disease through its reaching the body's organs and tissues; (iii) Sulfur Dioxide (So2) roots from burning fossil energy and natural sources such as volcanoes, and results in asthma and increased respiratory symptoms. Raaschou-Nielsen and Andersen et al (2013) pointed at that there is statistically significant association with lung cancer hazard ratio of 22% higher due to PM10, and 36% larger owing to PM2.5, for an increase of 10 μg/ m3 in the two types of atmospheric particle matters based on survey of 312,944 people in nine European countries[8]. Water soluble ions, such as anions $No3^-$ and $So4^{2-}$ in sulphate and nitrate, play a key role to produce PM, which are formed mainly from oxidation of So2 and NOx (Taiwo et al, 2014; Yin and Harrison, 2008)[4,9]. Thereupon then depict in the paper and explore the statistical direct influence on AQI (Air Quality Index) and PM from chemical and atmospheric factors.

Literatures indicate the current PM research preferences of chemical composition and characteristics[1-4], as well as, air pollution are studied through time series or conventional statistic analysis (Janssen et al, 2005; Mehta et al, 2014;)[10-11]. There are few research notices of the factor-influential differentia after and before Vehicle Limit Line. In the following key content, the author mainly gropes for the correlations between factors set-1 including 3 chemical (Co, No2, and So2) and 4 atmospheric (temperature, dew, humidity, and wind speed), and set-2 (AQI, PM2.5& PM10), and impacts in the 6 scenarios including the overall, workday and workend after and before Vehicle Limit Line in Tianjin, China.

## EMPIRICAL DATA

**TABLE 1 : Descriptive statistics**

| | After Vehicle Limit Line | | | | Before Vehicle Limit Line | | | |
|---|---|---|---|---|---|---|---|---|
| | **Min** | **Max** | **Mean** | **Std. Er.** | **Min** | **Max** | **Mean** | **Std. Er.** |
| AQI | 36 | 251 | 116.30 | 4.327 | 30 | 361 | 142.55 | 6.478 |
| Level | 1 | 5 | 2.81 | 0.087 | 1 | 5 | 3.19 | 0.108 |
| PM2.5 | 17 | 201 | 78.30 | 3.734 | 12 | 330 | 106.13 | 6.017 |
| PM10 | 21 | 272 | 136.31 | 5.298 | 22 | 476 | 169.39 | 8.386 |
| Co | 0.66 | 3.17 | 1.47 | 0.042 | 0.45 | 5.57 | 2.24 | 0.082 |
| No2 | 19 | 106 | 51.94 | 1.667 | 16 | 129 | 67.42 | 2.124 |
| So2 | 4 | 101 | 32.03 | 1.645 | 23 | 261 | 100.48 | 3.992 |
| Tem | 8 | 31 | 19.96 | 0.534 | -8 | 13 | 1.86 | 0.410 |
| Dew | -11 | 19 | 7.38 | 0.735 | -25 | 8 | -7.93 | 0.550 |
| Hum | 18 | 90 | 49.85 | 1.533 | 15 | 95 | 55.05 | 1.635 |
| Spd | 6 | 32 | 12.52 | 0.464 | 3 | 29 | 10.37 | 0.463 |

Base on data accumulation from the official websites, China Meteorological administration, Ministry of Environmental Protection of People's Republic of China, Tianjin Environmental Protection Bureau, and Tianjin Meteorological Bureau, 245 samplings are gained, and are almost averagely divided into 2 groups after and before Vehicle Limit Line. The descriptive Statistics can be browsed at TABLE 1. The variables comprise of the aforementioned factors and Level (the classification of AQI) enbodied the compositive explanation of pm2.5, pm10, So2, No2, O3, and Co etc, and which is ignored in the rear influential study.

## CORRELATION ANALYSIS

In the study, two sets of multi-dimensional variables are chosen, of which dimensionality reduction and discriminant analysis are customary techniques through building up associations of the lower-dimensional latent variables to bridge the relationship of two sets of explicit variables. Canonical correlation analysis (CCA) is a classical method to solve the problem[12]. In the 6 scenarios including the overall, workday and workend after and before Vehicle Limit Line, correlations between Set-1 and Set-2 are calculated and the marked data on histograms exposes the quantum of individual pairs shown at Figure 1. The stacked histograms express that correlations between Set-2 (Level, AQI& PM2.5) and set-1 (Co, No2& So2) have strictly similarity. And correlations between PM10 and set-1 (Co, No2& So2) show different sort orders, in which the biggest correlation is appeared on So2 after Vehicle Limit Line and No2 before Vehicle Limit Line, which indicates the decreed affinity on No2 appeared after Vehicle Limit Line.

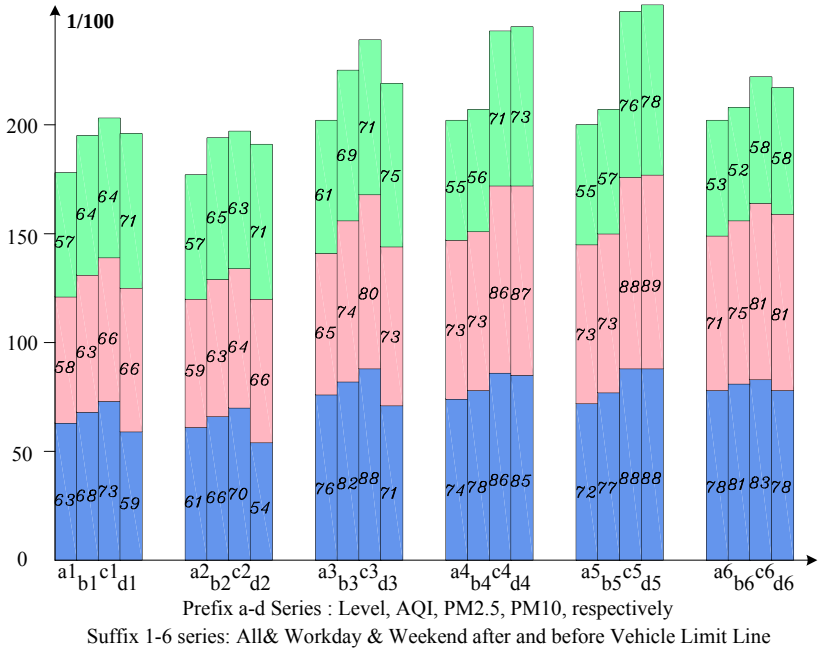



**Figure 1 : Stacked and clustered histograms of Correlations between Prefix a-d Series and Co (lower), No2 (middle) & So2 (upper) in the scenarios of Suffix 1-6 series**

**TABLE 2 : Statistic test**

| | After Vehicle Limit Line | | | | Before Vehicle Limit Line | | | |
|---|---|---|---|---|---|---|---|---|
| | **Wilk's** | **Chi-SQ** | **DF** | **Sig.** | **Wilk's** | **Chi-SQ** | **DF** | **Sig.** |
| Overall | 0.178 | 174.043 | 28 | 0 | 0.072 | 346.974 | 28 | 0 |
| Workday | 0.171 | 121.779 | 28 | 0 | 0.049 | 278.073 | 28 | 0 |
| Workend | 0.027 | 90.208 | 28 | 0 | 0.065 | 90.086 | 28 | 0 |

## DIRECT INFLUENTIAL ANALYSIS

CCA is also used to illustrate the regression relationship and compute standardized canonical coefficients for Set-1 and set-2. According to the calculation, there are four standardized canonical correlations, and test that remaining the first correlation is seen at TABLE 2.

Therefore, regression equations of the first standardized canonical correlation on set-1&2 are set up as follows. For set-1, regressions of the overall, workday and weekend data are shown at Equations 1-3 after Vehicle Limit Line, and at Equations 4-6 before Vehicle Limit Line.

**V= -0.299*Co-0.361*No2-0.538*So2-0.292 *Tem+0.285*Dew-0.300*Hum-0.163*Spd** **(1)**

**V= -0.222*Co-0.466*No2-0.561*So2-0.222 *Tem+0.136*Dew-0.337*Hum-0.299*Spd** **(2)**

**V=0.516*Co+0.285*No2+0.275*So2+0.566 *Tem-0.745*Dew+0.721*Hum+0.064*Spd** **(3)**

**V= 0.550*Co-0.427*No2-0.079*So2-0.240 *Tem+0.012*Dew-0.144*Hum-0.164*Spd** **(4)**

**V= -0.520*Co-0.483*No2-0.060*So2-0.225 *Tem+0.033*Dew-0.164*Hum-0.193*Spd** **(5)**

**V= -0.614*Co-0.345*No2-0.069*So2-0.351 *Tem+0.124*Dew-0.221*Hum-0.016*Spd** **(6)**

Set-2 regressions of the overall, workday and weekend data are shown at Equations 7-9 after Vehicle Limit Line, and at Equations 10-12 before Vehicle Limit Line.

**D= 0.191*Level+1.43*AQI-1.534*PM2.5- 1.117*PM10** **(7)**

**D= 0.345*Level+0.633*AQI-1.148*PM2.5- 0.867*PM10** **(8)**

**D= -0.18*Level-0.674*AQI+1.652*PM2.5+ 0.171*PM10** **(9)**

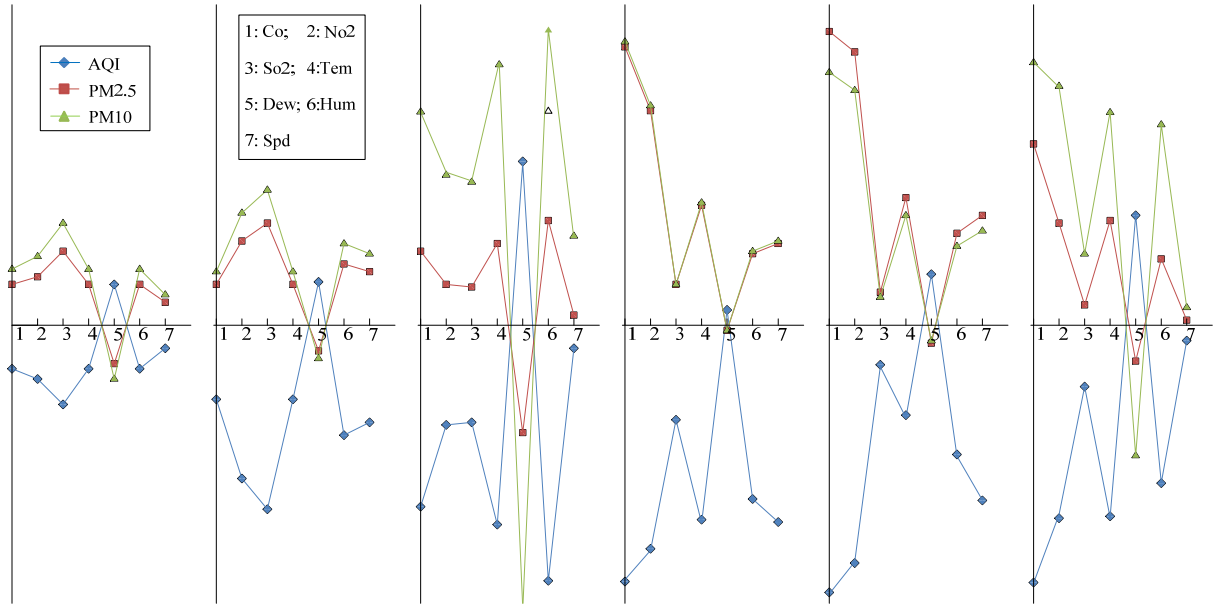
**D= -0.297*Level+0.197*AQI-0.468*PM2.5 -0.458*PM10** **(10)**

**D= -0.266*Level+0.154*AQI-0.424*PM2.5 -0.491*PM10** **(11)**

**D= -0.274*Level+0.26*AQI-0.786*PM2.5- 0.222*PM10** **(12)**

The direct influences of the variables between set-1 and set-2 can be perspicuously reflected at Figure 2, in which the affected trend is conformably explained in the mentioned 6 scenarios after and before Vehicle Limit Line. Meanwhile the discrepancy of the former lower and the latter higher

marginal effects are clearly demonstrated and concretely occurred, show at Figure 2. Generally, the direct influence on set-2 owes much more to Co and No2 before Vehicle Limit Line. The influential differences are alleviatory, and Co and No2 are obviously half cut down after Vehicle Limit Line, while at the weekend, the direct influence on PM10 is hysterical mutation.




**Prefix a-series: After Vehicle Limit Line; Prefix b-series: Before Vehicle Limit Line.**

**Suffix 1-series: All Data; Suffix 2-series: Workday Data; Suffix 3-series: Weekend Data**

**Figure 2 : Direct influence on AQI, PM2.5, & PM10 due to the 7 factors shown at the abscissas**

During the data collection after Vehicle Limit Line, the official data announced that the working cars per workday reached maximally about 32% of car ownership in Tianjin, which can verify the situation of comparison between (a2) and (a3) at Figure 2. The influences from the atmospheric factors are statistically coincident, that is, the affected AQI is an inverted trend against PM, and the influence from variable Dew is an adverse tendency against the other atmospheric factors.

## CONCLUSIONS

The data from the official websites are primitively aggregated to probe into the improved influences on AQI and PM in Tianjin. Accompanied on the solution of correlations and the test of significances, the direct influences on set-2 due to the 3 chemical and 4 atmospheric factors are measured. The study also designs 2 contexts and their 3 scenarios respectively to compare the affected diversification. The findings are as follows.

(1) In the paper, to gain lower multi- dimensions correlated maximally, CCA technique is adopted, and empirically, there is the austerely statistic significance of CCA regression at each scenario.

(2) The combined Co and No2's correlations with the factors of set-2 in context of non Vehicle Limit Line are analogical, the weekend of Vehicle Limit Line as well. In the other scenarios, the correlations diminish at large, and which validates the true situation. The correlations of So2 with set-2 seem to be steady-going during the data's span.

(3) The influential degrees of multi-factor regressions on weekend of Vehicle Limit Line have similar characteristics of non Vehicle Limit Line. As well as, the influence degrees on PM from Co, No2, and So2 are largely decreased on workday after Vehicle Limit Line. Although the influences of the atmospheric factors are synchronously occurred, their cross-influences are not calculated here, which evidently interferes their truly acted results.

## ACKNOWLEDGEMENTS

The study was funded through Tianjin Philosophy Social Science Fund with Approval No TJGL13-018, project foundations of Tianjin Municipal Education Committee (20122115) and Innovation Research of Management School on Tianjin Polytechnic University (GLKJCX20130013).

## REFERENCES

**[1]** Yan Cheng, Shuncheng Lee, Zhaolin Gu, Kinfai Ho, Yunwei Zhang, Yu Huang, Judith Chow, John Watson, Junji Cao, Renjian Zhang; PM2.5 and PM10-2.5 chemical composition and source apportionment near a Hong Kong roadway [J]. Atmospheric Environment, **83**, 35-42 **(2014)**.

**[2]** Melanie Fortune, Cameron Mustard, Patrick Brown; The use of Bayesian inference to inform the surveillance of temperature-related occupational morbidity in Ontario, Canada, 2004-2010 [J]. Environmental Research, **132**, 449-456 **(2014)**.

**[3]** Marco Pandolfi, Yolanda Gonzalez- Castanedo, Andrés Alastuey, Jesus D.de la Rosa, Enrique Mantilla, A.Sanchez de la Campa, Xavier Querol, Jorge Pey, Fulvio Amato, Teresa Moreno; Source apportionment of PM10 and PM2.5 at multiple sites in the strait of Gibraltar by PMF: impact of shipping emissions [J]. Environmental Science and Pollution Research, **18**, 260-269 **(2011)**.

**[4]** Adewale Taiwo, David Beddows, Zongbo Shi, Roy Harrison; Mass and number size distributions of particulate matter components: Comparison of an industrial site and an urban background site [J]. Science of the Total Environment, **475**, 29-38 **(2014)**.

**[5]** Aileen Yang, Aleksandra Jedynska, Bryan Hellack, Ingeborg Kooter, Gerard Hoek, Bert Brunekreef; Measurement of the oxidative potential of PM2.5 and its constituents: The effect of extraction solvent and filter type [J]. Atmospheric Environment, **83**, 35-42 **(2014)**.

**[6]** Yunli Zhao, Zhiqing Lin, Ruhan Jia, Guojun Li, Zhuge Xi, Dayong Wang; Transgenerational effects of traffic-related fine particulate matter (PM2.5) on nematode Caenorhabditis elegans [J]. Journal of Hazardous Materials, **274**, 106-114 **(2014)**.

**[7]** US- EPA; Our Nation's Air: Status and Trends through 2010 [R]. EPA-454/ R-12-001, United States Environmental Protection Agency, February, http://www. epa.gov/airtrends/ 2011/.US-EPA, 3 **(2012)**.

**[8]** Ole Raaschou-Nielsen, Zorana J.Andersen, Rob Beelen, Evangelia Samoli, Massimo Stafoggia, Gudrun Weinmayr, Barbara Hoffmann, Paul Fischer, Mark J.Nieuwenhuijsen, Bert Brunekreef et al.; Air pollution and lung cancer incidence in 17 European cohorts: prospective analyses from the European Study of Cohorts for Air Pollution Effects [J]. The Lancet Oncology, **14(9)**, 813-822 **(2013)**.

**[9]** Jianxin Yin, Roy M.Harrison; Pragmatic mass closure study for PM1.0, PM2.5 and PM10 at roadside, urban background and rural sites [J]. Atmospheric Environment, **42**, 980-988 **(2008)**.

**[10]** N.A.H.Janssen, T.Lanki, G..Hoek, M.Vallius, J.J.de Hartog, R.Van Grieken, J.Pekkanen, B.Brunekreef; Associations between ambient, personal, and indoor exposure to fine particulate matter constituents in Dutch and Finnish panels of cardiovascular patients [J]. Occupational and Environmental Medicine, **62**, 868-877 **(2005)**.

**[11]** Sumi Mehta, Hind Sbihi, Tuan Nguyen Dinh, Dan Vu Xuan, Loan Le Thi Thanh, Canh Truong Thanh, Giang Le Truong, Aaron Cohen, and Michael Brauer; Effect of poverty on the relationship between personal exposures and ambient concentrations of air pollutants in Ho Chi Minh City [J]. Atmospheric Environment, **95**, 571-580 **(2014)**.

**[12]** Richard A.Johnson, Dean W.Wichern; Applied Multivariate Statistical Analysis [M], 5th edition, Prentice Hall, Upper Saddle River, NJ, **(2002)**.