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AMBIENT AIR $PM_{2.5}$ PARTICULATES AND POLLUTANTS (CR, NI, CD, PB, HG(P), TGM, RGM, GEM) CONCENTRATIONS AND HEALTH RISK ASSESSMENT STUDY NEARBY AN AIRPORT IN CENTRAL TAIWAN

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Abstract: This study discussed the ambient air $PM_{2.5}$ and associated pollutant (Cr, Ni, Cd, Pb, Hg(p), TGM, RGM, GEM) concentrations and health risks of residents living nearby an Airport in central Taiwan. The sampling program was conducted during Sep. of 2016 ~ Feb. of 2017. $PM_{2.5}$ was measured by using a Wilbur $PM_{2.5}$ sampler. Metallic elements (Cr, Ni, Cd, Pb) were analyzed by using the ICP-OES analyzer. The results indicated that the average concentration of $PM_{2.5}$ was 23.2 μg/m^3In addition, the autumn has the highest mean mass, Cr, Ni, TGM, GEM and RGM concentrationswhilethe winter has the highest mean Cd, Pb and Hg(p) concentrations. Finally, the carcinogenic risks via inhalation exposure to Cr, Ni, and Cd in $PM_{2.5}$ for children and adults were higher than 1 $\times 10^{-6}$ set by the US EPA. The calculated non-carcinogenic risk (Cr, Ni, Cd, GEM and Hg(p)) was below 1..

Keywords: $PM_{2.5}$, Metallic elements, TGM, RGM, GEM

I. METHODOLOGY

Figure 1 display the geographical location at airport sampling nearby site (24°15'00.0"N 120°35'56.9"E) in central Taiwan. Ambient particulate, metal elements (Cr, Ni, Cd, Pb), Hg(p), TGM, RGM and GEM concentrations were sampled on the roof of the school building at airport nearby, and three-story building about 9 m height at the medium of Da Du Mountain. There were 6,400 vehicles pass by during the day time working hours at this Taiwan Formosa expressed 3 high way. And there were 12,000 vehicles pass by during the night time working hours at this Taiwan Formosa expressed 3 high way. In addition, Taichung International Airport (TIA), port of Taichung which believe to be the main pollutants sources were scattered around this sampling site.

Figure 1 Geographical location at airport sampling nearby site in central Taiwan.

1.1. Wilbur PM 2.5 Sampler

This ambient air sampler device can be used to collect ambient air particulates with diameters of under 2.5 μm. The maximum pressure drop of a clean filter with at 16.67 L/min clean air flow is 30 cm of a water column. The allowed working temperature range was -25℃~50℃.

1.2. Four-stage gold amalgamation and denuder

These four-stage gold amalgamation sampling device. It was used to collect total gaseous mercury (TGM) concentration and were composed of from little amalgam. The total sampling period is 24hrs with flow rate 0.25 (m3/min). The denuder sampling device and heating system inside the insulated box consisted of a pair of general radiant heaters mounted inside the case and a pair of electronic temperature controlled (proportional, integral, and derivative PID) heating sleeves that were placed directly over the denuders to maintain 50°C.

1.3. Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES)

About procedure all the samples will kept 24 hrs. at 4 ℃ before analyzed by ICP-OES. The analysis conditions were set at 30 sec delay time and the nebulizer flow rate was set at 0.65 L/min. The argon gas plasma flow rate set at 15 L/min and the injection sample flow rate was set at 1.5 ml/min.

1.4.Cold-vapor atomic fluorescence spectrometry

Air was pulled through the vapor-phase sampling system using a mass-flow-controlled vacuum pump at a nominal flow rate of 0.3 L/min. Determination of vapor- and particle-phase mercury in ambient air was accomplished using dual-amalgamation Cold-Vapor Atomic Fluorescence Spectrometry (CVAFS) (Brook Rank, USA).

II. RESULTS AND DISCUSSION

2.1. Particulates, metal elements and mercury concentrations

Table 1 displayed the sampling results indicated that the average particulates concentrations were26.730

µg/m^{3}for autumnat airport. In addition, the sampling results indicated that the particulates concentrations were18.533 µg/m^3 inwinter at airport.

The sampling results also indicated that the mean metal elements (Cr, Ni, Cd andPb) concentrations were25.602, 49.227, 1.657 and 2.162ng/m^3 for autumn at airport. In addition, the sampling results indicated that the mean metal elements (Cr, Ni, Cd andPb) concentrations were15.462, 10.670, 1.784 and 3.382 ng/m^3 in winter at airport.

Moreover, the sampling results indicated that the average mercury (TGM, RGM, GEM and Hg(p)) concentrations were5.147, 5.143 ng/m^3, 3.956 and 1.936pg/m^3 for autumn at airport. In addition, the sampling results indicated that the mean mercury (TGM, RGM, GEM and Hg(p)) concentrationswere2.577, 2.197 ng/m^3, 1.972 and 4.381pg/m^{3}in winter at this airport.

2.2. Health risk assessment

Table 2 displays the carcinogenic risks from toxic elements in $PM_{2.5}$ via inhalation and ingestion exposure at airport.Results of the carcinogenic risks from toxic elements for this study revealed that the carcinogenic risk for the element Cr, Ni, Cd and Pb were 2.36×10^{-4}, 6.15×10^{-7}, 5.82×10^{-7} and 2.63×10^{-9} at the ages of 0-2 years, respectively.

In addition, results of the carcinogenic risks from toxic elements for this study revealed that the carcinogenic risk for the element Cr, Ni, Cd and Pb were 2.96×10^{-3}, 7.71×10^{-6}, 7.30×10^{-6} and 3.29×10^{-8} at the ages of 0-16 years, respectively. Moreover, results of the carcinogenic risks from toxic elements for this study revealed that the carcinogenic risk for the element Cr, Ni, Cd and Pb were 3.38×10^{-3}, 8.81×10^{-6}, 8.34×10^{-6} and 3.76×10^{-8} at the ages of 0-30 years, respectively. Finally, results of the carcinogenic risks from toxic elements for this study revealed that the carcinogenic risk for the element Cr, Ni, Cd and Pb were 4.82×10^{-3}, 1.25×10^{-5}, 1.19×10^{-5} and 5.36×10^{-8} at the ages of 0-70 years, respectively.

Results of non-carcinogenic risk from toxic elements for this study revealed that the non-carcinogenic risk for element Cr, Ni, Cd, GEM and Hg(p) were 1.30×10^{-4}, 3.78×10^{-4}, 1.09×10^{-4}, 7.73×10^{-6} and 6.65×10^{-9} at the ages of 0-2 years, respectively.In addition, results of non-carcinogenic risk from toxic elements for this study revealed that the non-carcinogenic risk for element Cr, Ni, Cd, GEM and Hg(p) were 2.19×10^{-4}, 6.38×10^{-4}, 1.83×10^{-4}, 1.30×10^{-5} and 1.12×10^{-8} at the ages of 0-16 years, respectively.

Moreover, results of non-carcinogenic risk from toxic elements for this study revealed that the non-carcinogenic risk for element Cr, Ni, Cd, GEM and Hg(p) were 2.60×10^{-4}, 7.59×10^{-4}, 2.18×10^{-4}, 1.55×10^{-5} and 1.33×10^{-8} at the ages of 0-30 years, respectively. Finally, results of non-carcinogenic risk from toxic elements for this study revealed that the non-carcinogenic risk for element Cr, Ni, Cd, GEM and Hg(p) were 2.97×10^{-4}, 8.65×10^{-4}, 2.49×10^{-4}, 1.77×10^{-5} and 1.52×10^{-8} at the ages of 0-70 years, respectively.

III. CONCLUSIONS

3.1. Particulates, metal elements and mercury concentration

Autumn has the highest average mass, Cr, Ni, TGM, GEM and RGM pollutants concentrations and the values were 26.730 µg/m^3, 25.602, 49.227, 5.147, 5.143 ng/m^3 and 3.956 pg/m^3, respectively.In addition winter has the highest average Cd, Pb and Hg(p) pollutants concentrations and the values were 1.784, 3.382 ng/m^3 and 4.381 pg/m^3, respectively.

3.2. Health risk assessment

The carcinogenic risks via inhalation exposure for children and adultsto elements Cr in $PM_{2.5}$ washigher than those of US EPA acceptable values of 1×10^{-6} and1×10^{-4}.This sampling site was above the US EPA acceptable values.High carcinogenic risk existed for children and adults if they were continued exposed to those high pollutants concentrations.The carcinogenic risks via inhalation exposure for children to elements Ni and Cd in $PM_{2.5}$ were higher than those of US EPA acceptable values of 1×10^{-6}.This sampling site was above the US EPA acceptable values.High carcinogenic risk existed for children if they were continued exposed to those high pollutants concentrations.

The carcinogenic risks via inhalation exposure for children and adultsto elements Pb in $PM_{2.5}$ was below than those of US EPA acceptable values of 1×10^{-6} and1×10^{-4}.This sampling site was almost above the US EPA acceptable values.

In addition, the non-carcinogenic risks via inhalation exposure for children and adultsto elements (Cr, Ni, Cd, GEM and Hg(p)) in $PM_{2.5}$ wereall below than 1.This result further indicated that all the metallic elements were harmful free to human health at thus sampling site.

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Data		Mass	Cr	Ni	Cd	Pb	TGM	GEM	RGM	Hg(p)
		μg/m³	ng/m³						pg/m³	
Autumn	*Sep.*	17.040	37.099	46.050	1.493	2.790	6.624	6.620	3.674	2.701
	Oct.	49.130	19.630	56.643	1.51	1.785	4.748	4.744	3.743	0.920
	Nov.	14.020	20.077	44.990	1.97	1.910	4.071	4.066	4.451	2.186
Average		26.730	25.602	49.227	1.657	2.162	5.147	5.143	3.956	1.936
Winter	*Dec.*	23.730	11.249	7.961	1.379	4.948	3.981	3.978	3.454	13.024
	Jan.	16.800	10.548	5.296	1.684	2.382	1.666	1.665	1.326	0.044
	Feb.	15.070	24.590	18.753	2.288	2.815	2.085	0.950	1.135	0.074
Average		18.533	15.462	10.670	1.784	3.382	2.577	2.197	1.972	4.381
Mean		23.217	21.256	32.703	1.711	2.685	4.046	3.881	3.106	2.984

Table 1 Ambient air pollutants (particulates, metallic elements and mercury species (TGM, GEM, RGM)) concentrations in PM2.5 at airport sampling nearby site in central Taiwan

	Mean (μg/m³)	Exposure concentration via inhalation (mg/kg/day)				Inhalation Cancer Potency Factor (mg/kg-d)⁻¹	Inhalation caner concentrations (mg/m³)	Carcinogenic risk				Non carcinogenic risk			
		0<2 years	2-16 years	16-30 years	16-70 years			0<2 years	0<16 years	0<30 years	0<70 years	0<2 years	2<15 years	16<30 years	16<70 years
Cr	2.05E-02	1.30E-05	8.91E-06	4.14E-05	3.65E-06	5.10E+02	1.00E-04	2.36E-04	2.96E-05	3.38E-05	4.82E-05	1.30E-04	8.91E-05	4.14E-05	3.65E-05
Ni	2.99E-02	1.89E-05	1.50E-05	6.04E-06	5.52E-06	9.10E-01	5.00E-05	6.15E-07	7.71E-06	8.81E-06	1.25E-05	3.78E-04	3.00E-04	1.21E-04	1.06E-04
Cd	1.72E-03	1.09E-06	7.47E-07	3.47E-07	3.06E-07	1.50E+01	1.00E-05	5.82E-07	7.30E-06	8.34E-06	1.19E-05	1.09E-04	7.47E-05	3.47E-05	3.06E-05
Pb	2.77E-03	1.75E-06	1.20E-06	5.59E-07	4.92E-07	4.20E-02		2.63E-09	3.29E-08	3.76E-08	5.30E-08				
TGM	3.86E-03	2.44E-06	1.68E-06	7.79E-07	5.86E-07										
GEM	3.67E-03	2.32E-06	1.59E-06	7.40E-07	6.57E-07		3.00E-04					7.73E-05	5.31E-06	2.47E-06	2.17E-06
RGM	2.96E-06	1.87E-09	1.29E-09	5.98E-10	5.26E-10										
Hg(p)	3.16E-06	1.99E-09	1.37E-09	6.37E-10	5.51E-10		3.00E-04					6.65E-09	4.57E-09	2.17E-09	1.87E-09

Table 2 Carcinogenic and non- carcinogenic risk assessment values for Cr, Ni, Cd, Pb, Hg(p), TGM, RGM and GEM at airport sampling nearby site.