INDUSTRIAL PARTICULATE POLLUTION AND RISK OF GENETIC DAMAGE AMONG PRIMARY SCHOOL CHILDREN IN TERENGGANU

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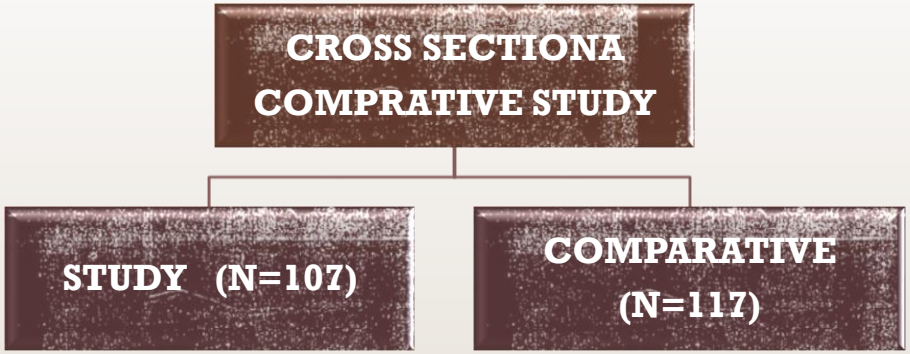
INTRODUCTION

- The incremental of air pollutants loading in most of urban and industrial area are pernicious, especially to the **sensitive group like children** as it able to impair their health (Seifi et al., 2019, Suhaimi et al., 2017)
- Children are more susceptible to the negative effects of air pollutants than adults due to their **under-developed physical and biological condition** (Esposito et al., 2014).
- Prolonged exposure to highly polluted area may increase risk of respiratory illness and cancer especially among sensitive receptor who living near to heavy industries, like petrochemical industry.
- To date, there is **limited study** on association of air pollutants exposure and genotoxic outcome have been conducted among children population in Malaysia.
- This study aims to **evaluate association of air pollutants on potential genotoxic outcome, as indicates by micronucleus frequency and DNA damage (tail moment and olive moment) among primary school children living in the vicinity of petrochemical industry**

METHODOLOGY



INCLUSION CRITERIA

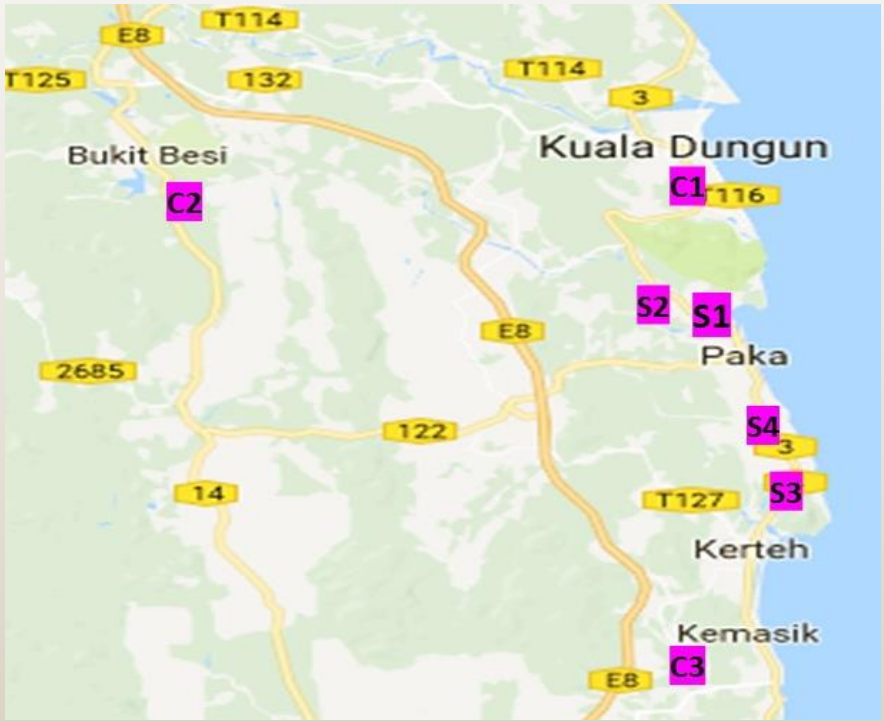
- Primary school children aged between 9 to 10 years old
- registered and attending the selected schools
- Malaysian citizen
- Malay ethnicity
- Living within the same area of their school
- Free from history of doctor diagnosed chronic disease

EXCLUSION CRITERIA

- Primary school children with a known history of medical problems
- Respondent who had radiotherapy or chemotherapy in the previous 12 months or X-rays in the previous 3 months
- Respondent with family history of cancer
- Respondent who do not get consent to participate in this study

STUDY LOCATIONS

Figure 3



Schools	Distance from industry (km)
S1	5.6
S2	4.4
S3	2.2
S4	3.7
C1	35.96
C2	20.85
C3	20.66

$PM_{2.5}$ SAMPLING

Dry filter in desiccator 24H → Weighing Filter → Dry in desiccator 24H → Place in MiniVol

Type filter: QUARTZ
Diameter: 47 mm

5 decimal balance

Flow rate: 5 L/min, Duration sampling: 24 HOURS

INDOOR AIR QUALITY ASSESSMENT

BUCCAL CELL COLLECTION

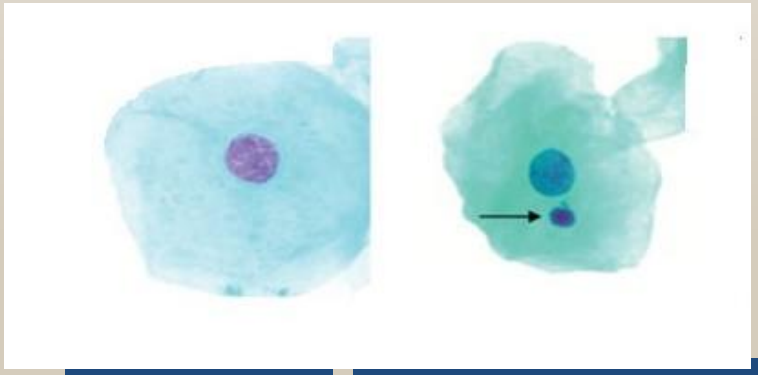
Rinse mouth (3x)

Rotate brush 3x in a gently spiral motion

Dipped into a tube of 1 mL of PBS 0.1 M

Kept in a cool box & transported to laboratory

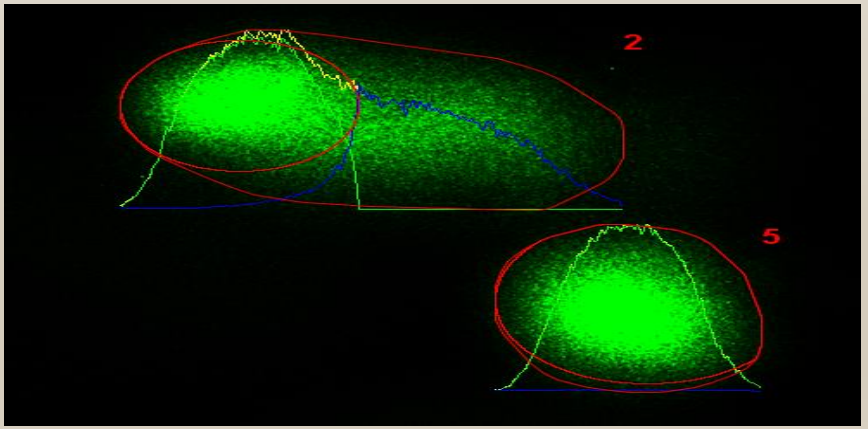
MICRONUCLEUS ASSAY AND COMET ASSAY



A: normal cell

B: cell with micronucleus

Micronucleus derived from acentric chromosome fragments or whole chromosomes which fail to migrate to spindle poles during anaphase



Cell with longer comet tail indicates greater DNA damage, meanwhile cell with shorter tail and intact head indicates minimal DNA damage.

FINDINGS

Table 1: Comparison of Indoor & Outdoor $PM_{2.5}$ (24H) Concentration

Variables	Exposed schools (n=18)	Comparative schools (n=10)	T value	P value
	Mean±SD	Mean±SD		
Indoor (I) μg/m³	30.19±9.64	18.43±7.14	3.21	0.004*
Outdoor (O) μg/m³	43.00±12.64	51.76±19.61	-1.38	0.178
Ratio (I/O)	0.72±0.20	0.42±0.22	3.55	0.002*

N=28, Independent T-Test, *Significant at p<0.05

Table 2: Comparison of the indoor air pollutants between the schools (5H school hour)

Variable	Exposed school	Comparative schools	z-value	p-value
	Median (IQR)			
PM_{10} (μg/m³)	40.00(28.00)	26.00(7.75)	-2.752	0.006*
$PM_{2.5}$ (μg/m³)	41.00(28.00)	27(6.75)	-2.793	0.005*
PM_{10} (μg/m³)	77.00(35.00)	34(8.50)	-3.643	<0.001*
T (°C)	28.91(0.91)	29.15(1.66)	-0.622	0.534
RH (%)	77.70(3.43)	75.28(9.51)	-0.700	0.484
V (m/s)	0.26(0.26)	0.33(0.61)	-1.395	0.163
CO_2 (ppm)	493.00(62.50)	344.88(27.91)	-3.179	0.002*

N=20, Mann-Whitney U test, * significant at p<0.05 *LD: below detection limit

- Concentration of indoor $PM_{2.5}$ (24H) at the exposed schools were **significantly higher (p<0.05)** than the comparative schools. But the pollutants is still below the standard limit of the New Malaysia Ambient Air Quality Standard.
- The values of **Indoor/Outdoor (I/O) ratios of 24 hours measured $PM_{2.5}$ ranged from 0.34 to 0.74, which suggested high penetration of outdoor particles into the indoor classrooms**
- The indoor air quality during the schools' hours demonstrated a significant concentration of particulate matter in the exposed classrooms

PATTERN ON PARTICLE DISTRIBUTION

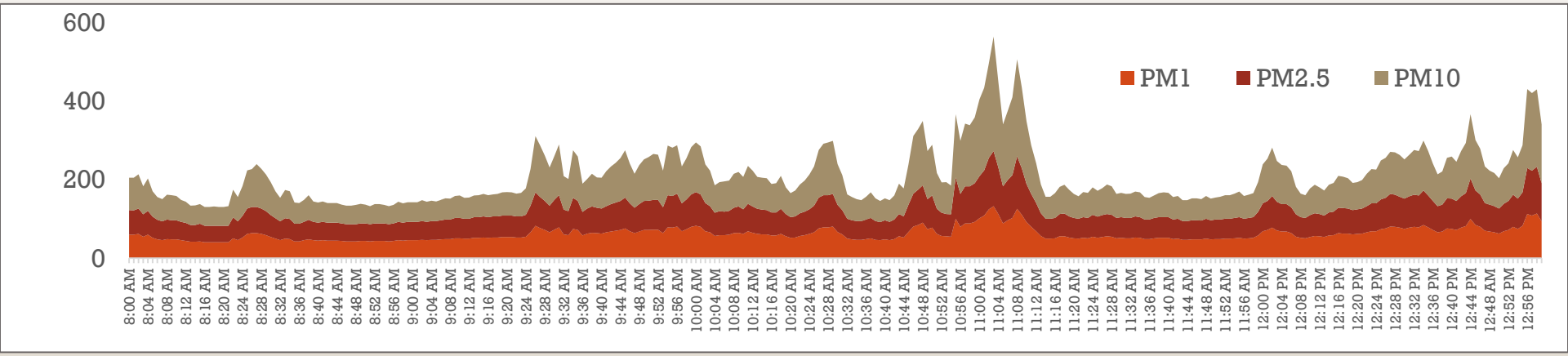


Fig 1: 5 h' time series on indoor PM_1, $PM_{2.5}$ and PM_{10} in classroom

- Relatively high concentrations were observed during the **first 30 min** when the children entered the classrooms, due possibly to a lot of movement to get to their seats, to get their books from the bookshelves as well as the daily routine of sweeping the floor clean.
- High levels of particulate were also observed during the recess time due to **the re-suspension of the particles caused by the movement of the children** (Yang Razali et al., 2015; Ismail et al 2010).
- The active movement also tended to increase the air turbulence, leading to high uplifting of indoor particles (Madureira et al., 2015).

Variables	Exposed group (n=107)		Comparative group (n=117)		Z-value	P value
	Mean±SD	Med(IQR)	Mean±SD	Med(IQR)		
Micronuclei frequency	4.80±3.36	4.00(5.00)	2.39±1.61	2.00(2.00)	-6.46	<0.001
Olive moment	15.76±4.59	15.29(5.23)	11.99±2.72	11.83(3.39)	-7.53	<0.001
Tail moment	27.20±8.21	26.43(9.88)	21.03±4.88	20.65(5.70)	-7.42	<0.001

Variable	More likely present MN (MN>3) N (%)	Less likely present MN (MN<3) N (%)	x^2	p	PR	95%CI
High PM_1 (> 32.5 µg/m³)	59(52.7)	53(47.3)	0.018	0.894	1.017	0.792-1.307
Low PM_1 (< 32.5 µg/m³)	58(51.8)	54(47.3)				
High $PM_{2.5}$ (> 36µg/m³)	81(66.4)	41(33.6)	21.54	<0.001**	1.881	1.405-2.518
Low $PM_{2.5}$ (< 36 µg/m³)	36(35.3)	66(64.7)				
High PM_{10} (< 49 µg/m³)	80(66.1)	41(33.9)	20.33	<0.001**	1.841	1.380-2.454
Low PM_{10} (< 49 µg/m³)	37(35.9)	66(64.1)				
N=235,Chi Square Test, * Significant at p<0.05 ** Significant at p<0.001						

- **Micronuclei frequency, olive moment and tail moment of the exposed children are significantly higher than comparative group.**
- **Significant associations between air pollutants concentration** ($PM_{2.5}$ PM_{10}) in schools with micronuclei (Mn) frequency which suggests that **inhalation of particulate matters are likely to induce formation of micronuclei in buccal cell of children.**

Variable	High Olive moment >12.91 N(%)	Low Olive moment <12.91 N(%)	x^2	p	PR	95% CI
High PM_1 (> 32.5 µg/m³)	70(57.9)	51(42.1)	5.82	0.016*	1.374	1.056-1.788
Low PM_1 (< 32.5 µg/m³)	48(42.1)	66(57.9)				
High $PM_{2.5}$ (> 36µg/m³)	93(72.1)	36(27.9)	54.77	<0.001**	2.578	1.854-3.585
Low $PM_{2.5}$ (< 36 µg/m³)	25(23.6)	81(76.4)				
High PM_{10} (< 49 µg/m³)	92(71.9)	36(28.1)	52.77	<0.001**	2.958	2.081-4.204
Low PM_{10} (< 49 µg/m³)	26(23.3)	81(75.7)				

N=235,Chi Square Test, PR: prevalence rate* Significant at p<0.05 ** Significant at p<0.001,

- **Significant associations between air pollutants concentration** (PM_1, $PM_{2.5}$, PM_{10}) in schools with olive tail moment, which suggests that **inhalation of particulate matters are likely to induce longer comet tail or olive moment that** indicate the greater DNA damage effect among children (***Table 4).***
- **Children who exposed to high $PM_{2.5}$ and PM_{10} having 3 times likely tendency to experience DNA damage.**
- Thus, it indicates that **higher magnitude exposure to these pollutants may increase risk of genotoxic event** as parallel to finding in Gamboa et al (2008) and Ruchirawat et al (2007).

CONCLUSION

- This study reveals that the primary school children who resided nearby the industry were exposed to higher concentration of indoor air pollutants ($PM_{1,}$ $PM_{2.5,}$ $PM_{10,}$) as compared to those in the location far from the industry and had increased risk of genotoxic effect.
- The indoor particulate matter were significantly associated with chromosomal damage as indicated by micronuclei formation. The olive moment also significantly associated with the pollutant. Thus, this study supports the claims that both biomarkers can be applied in understanding relative contribution of industrial and air pollution as a risk factor of cancer and facilitate health risk assessments.

RECOMMENDATION

- Significant role of industry in mitigating and reducing industrial air pollutant exposure to nearby residence (pollution preventive measure, eg: green buffer zone
- Effective housekeeping program and frequent cleaning in schools and homes.
- Further research will be conducted in investigating the potency of composition particulate matter in inducing chronic health outcome among children

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