Trans. Nat. Acad. Sci.
Technol. 15: 377-393.1993

THE POLYCYCLIC AROMATIC HYDROCARBON PROFILE OF POLLUTED AIR IN METRO MANILA

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ABSTRACT

Portable Shibata samplers were used in collecting samples of indoor and outdoor air in Metro Manila. Air samples were also collected by student commuters to the University of the Philippines to determine the extent of personal exposure to polluted air.

A highly sensitive automatic method was developed to determine the extent of pollution by polycyclic aromatic hydrocarbons in Metro Manila air. This method revealed that benzo(ghi)perylene, a co-carcinogen and benzo(a)pyrene, a carcinogen, are present in appreciable amounts in Metro Manila air.

This was correlated with chromosome breaking effects exhibited by indoor and outdoor air samples collected around Metro Manila in a span of three years.

Personal exposure to polycyclic aromatic hydrocarbons of student commuters to the Unviersity of the Philippines, Diliman was assessed.

Benzo(ghi)perylene enhanced the genotoxicity of benzo(a)pyrene, methylcholanthrene and dimethylnitrosamine (three carcinogens) not only in bone marrow cells but also in germ cells.

INTRODUCTION

More than 500,000 motor vehicles ply the streets of Metro Manila. Some are diesel -powered and several are smoke belchers.

It is possible that diesel exhausts would introduce polycyclic aromatic hydrocarbon pollutants into the air of Metro Manila.

Meanwhile, cigarette smoke can pollute indoor air especially in rooms that are poorly ventilated. Cigarette smoke is a very rich source of polycyclic aromatic hydrocarbons and several other genotoxins (Sylianco, 1990).

Genotoxins from indoor and outdoor air can alter the structure of DNA in somatic cells, germ cells and cells during organogenesis (Sylianco, 1990). Unrepaired structural alterations in DNA of somatic cells can induce cancer. Unrepaired changes in DNA of germ cells may lead to sterility or high incidence of dead implants.

MATERIALS AND METHODS

Shibata portable air samplers were gifts from Dr. H. Matsushita, director of the Institute of Public Health, Tokyo, Japan.

Swiss Webster mice were provided by the College of Veterinary Medicine, University of the Philippines.

Fetal calf serum was purchased from Grand Island Biological Supply, Grand Island, N.Y.

Benzo(ghi)perylene, benzo(a)pyrene, methylcholanthrene and dimethylnitrosamine were supplied by Sigma Chemical Company, St. Louis, Missouri.

Quartz fiber filters were used to collect air particulates from indoor and outdoor air, with a flow rate of 1 liter per minute. Each filter was used for 24 hours. Five filters were used for each sampling station.

For the determination of polycyclic aromatic hydrocarbon profile, quartz fiber filters were sent to the Institute of Public Health, Tokyo Japan.

Organic extracts of the air particulates were used in the Host-Mediated Assay (Moriya, 1980), Micronucleus test (Schmid, 1976) and Dominant Lethal test (Generoso, 1980). Quartz fiber filters were extracted with acetone in a Soxhlet apparatus for one hour. The acetone extracts were concentrated to dryness with a rotary evaporator. The residue was dissolved in dimethylsulfoxide (5 mg/ml) and used for genotixicity tests.

Benzo(a)pyrene from air particulates was separated by Soxhlet extraction using benzene-ethanol solvent (4 :1 v/v). This extract was concentrated in a rotary evaporator to 2 ml. Benzo(a)pyrene spot was separated by thin layer chromatography on silica gel, developed by methanol-acetone mixture (1:1, v/v). Ultraviolet radiation was used to localize the benzo(a)pyrene spots. The concentration of benzo(a)pyrene was quantitatively determined by spectrofluorometry at an excitation wavelength of 525 nm and fluorescence emission wavelength of 545 nm (Matsushita, 1976).

In the micronucleus test for chromosome breaking effects, two administrations by oral gavage (24 hours apart) of the organic extracts of the air particulates were done using Swiss Webster mice.

In the host-mediated assay, the organic extracts were administered by oral gavage to Swiss Webster mice while the indicator organism (S. typhimurium His G 46) was administered intraperitoneally. Three hours after intraperitoneal injection, the indicator organism was removed from the peritoneal cavity and mutation frequency was determined.

For the dominant lethal test, organic extracts were given by oral gavage to male Swiss Webster mice. After six days, these were mated with virgin females. Every morning, females were examined for vaginal plugs. Plugged females were separated from the males. On the 18th day, pregnant females were dissected and live and dead implants were recorded.

RESULTS AND DISCUSSION

Table 1 shows the polycyclic hydrocarbon profile of indoor air samples from Metro Manila. This is compared with the profile of Kawasaki district in Japan. the data revealed that Metro Manila air is more polluted by polycyclic aromatic hydrocarbons than Kawasaki air. Benzo(ghi)perylene, a co-carcinogen and benzo(a)pyrene, a carcinogen, occur in appreciable amounts.

Data in Table 2, and in Figure 1, show that after metabolic activation, appreciable genotoxicity was observed in organic extracts of air particulates from outdoor air samples from areas which were either close to commercial centers or industrial centers. These areas were Quezon City, Marikina and Manila. Appreciable mutagenic activity after metabolic activation was exhibited in extracts of air particulates from air samples taken in Quezon City, Marikina and Pasig where some family members were cigarette smokers. The same observation was made of solvent extracts from kitchen air particulates in Parañaque, Pasig, Malabon, Makati and Cainta where kitchens were poorly ventilated.

Significant chromosome breaking effects were observed in organic extracts of air particulates from outdoor air in Quezon City, Caloocan City, Malabon, Manila and Parañaque (Table 3 and Fig. 2).

Appreciable concentrations of benzo(a)pyrene, a carcinogen, was detected in organic extracts of air particulates from outdoor air samples in Quezon City, Manila, Malabon, Caloocan and Parañaque- (Table 4 and Fig. 3). This polycyclic aromatic hydrocarbon can be emitted through diesel exhausts from motor vehicles.

Significant amounts of benzo(a)pyrene were shown in bedroom samples where some members of the family smoked cigarettes. Poorly ventilated kitchens showed appreciable amounts of this carcinogen.

Personal exposure to genotoxins while commuting to the University of the Philippines, Diliman was assessed in organic extracts of air particulates collected by Shibata portable samplers worn by students taking public utility vehicles which were not air-conditioned. Exposure to pro-mutagens was signficant for all commuters (Table 5 and Fig. 4).

Benzo(ghi)perylene, which occurs in highest amounts in Metro Manila air, enhanced the chromosome breaking effects of three carcinogens, benzo(a)pyrene, methylcholanthrene and dimethylnitrosamine (Table 6 and Fig. 5). It also enhanced the germ cell genotoxicity of these carcinogens (Table 7 and Fig. 6).

CONCLUSION

The polycyclic aromatic hydrocarbon profile of Metro Manila air revealed that benzo(ghi)perylene, a co-carcinogen, occurs in highest amounts. A carcinogen, benzo(a)pyrene, ranks second to benzo(ghi)perylene.

Outdoor air near heavy-traffic-areas and near industrial sites exhibited appreciable genotoxic activity. Indoor air of residences of cigarette smokers showed significant chromosome breaking effects. Genotoxic activity of air samples from poorly ventilated kitchens was appreciable. Commuters in non-airconditioned public utility vehicles were exposed significantly to genotoxins in polluted Metro Manila air.

Benzo(ghi)perylene, a co-carcinogen which occurs in highest amounts in Metro Manila air, enhanced the genotoxic activity of benzo(a)pyrene, a carcinogen present in polluted Metro Manila air. It also enhanced the gentoxicity of dimethylnitrosamine and methylcholanthrene, carcinogens present in cigarette smoke. Enhancement was shown in the genotoxic activity of these carcinogens on bone marrow cells and also on germ cells.

ACKNOWLEDGMENT

Financial support for three years from the Natural Science Research Institute, University of the Philippines, is gratefully acknowledged.

Table 1. PAH concentrations indoors in Kawasaki and Manila (unit: ng/m^3)

	max.	min.	mean
Kawasaki, Japan			
(ktchen, n=7)			
pyrene	1.85	0.52	0.91
BaA	1.62	0.17	0.54
BkF	2.52	0.42	1.18
BaP	5.05	0.66	2.28
BghiP	6.07	1.58	3.89
(living room, n=7)			
pyrene	1.94	0.52	0.92
BaA	1.58	0.22	0.48
BkF	2.43	0.40	1.13
BaP	4.79	0.42	2.20
BghiP	6.03	1.71	3.85
(outdoor, n=4)			
pyrene	1.01	0.36	0.75
BaA	0.63	0.21	0.48
BkF	1.84	0.44	1.19
BaP	2.64	0.56	1.84
BghiP	5.61	1.86	4.02
Manila, Philippines			
(kitchen, n=10)			
pyrene	4.29	0.53	1.64
BaA	4.45	0.34	1.48
BkF	4.65	0.67	1.95
BaP	10.14	0.96	3.70
BghiP	20.55	2.28	7.95
(living room, n=10)			
pyrene	5.04	0.43	1.67
BaA	4.35	0.25	1.47
BkF	6.19	0.42	2.13
BaP	9.64	0.57	3.34
BghiP	24.96	1.44	8.14
(outdoor, n=10)			
pyrene	3.69	0.57	1.58
BaA	2.49	0.43	1.36
BkF	3.50	0.67	1.88
BaP	4.35	0.81	2.54
BghiP	13.18	1.94	6.69

BaA: benz(a)anthracene, BkF: benzo(k)fluoranthene, BaP: benzo(a)pyrene, BghiP: benzo(ghi)perylene

Table 2. Genotoxic activity after metabolic activation of organic extracts of air particulates from indoor and outdoor air in Metro Manila

	Mutation Frequency of S-typhimurium His G-46		
Positive Control		*13.56 ± 2.31*	
Negative Control		*1.26 ± 0.09*	
		Air	
	Bedroom	*Kitchen*	*Outdoor*
Cainta	1.27 ± 0.07	3.67 ± 0.11	1.23 ± 0.11
Caloocan City	1.87 ± 0.34	2.93 ± 0.67	2.11 ± 0.23
Makati	3.50 ± 0.12	4.07 ± 0.67	1.89 ± 0.32
Malabon	1.07 ± 0.05	3.67 ± 0.89	1.11 ± 0.36
Manila	6.78 ± 0.97	1.34 ± 0.76	11.02 ± 1.12
Marikina	9.11 ± 0.95	1.27 ± 0.08	9.87 ± 0.34
Parañaque	1.20 ± 0.65	6.34 ± 0.57	1.23 ± 0.76
Pasig	4.82 ± 0.25	4.20 ± 0.77	1.54 ± 0.76
Quezon City	9.87 ± 0.98	1.32 ± 0.66	13.11 ± 1.23
Valenzuela	1.39 ± 0.12	1.13 ± 0.32	1.87 ± 0.21

Table 3. Chromosome breaking effects of organic extracts of air particulates from indoor and outdoor air in Metro Manila

	No. of Micronucleated Polychromatic Erythrocytes per Thousand		
Positive Control		*7.57 ± 0.34*	
Negative Control		*1.04 ± 0.21*	
		Air	
	Bedroom	*Kitchen*	*Outdoor*
Cainta	1.07 ± 0.89	3.33 ± 0.98	1.21 ± 0.98
Caloocan City	1.23 ± 0.34	1.31 ± 0.43	4.63 ± 0.67
Makati	5.43 ± 0.98	4.21 ± 0.67	1.21 ± 0.59
Malabon	1.12 ± 0.23	1.09 ± 0.34	4.67 ± 0.78
Manila	4.23 ± 0.56	1.22 ± 0.21	3.89 ± 0.54
Marikina	1.87 ± 0.45	1.27 ± 0.24	1.09 ± 0.36
Parañaque	1.07 ± 0.22	1.20 ± 0.11	3.47 ± 0.65
Pasig	5.11 ± 0.94	3.98 ± 0.76	1.78 ± 0.22
Quezon City	6.22 ± 0.23	5.43 ± 0.96	4.76 ± 0.89
Valenzuela	1.33 ± 0.22	1.23 ± 0.34	1.56 ± 0.31

Table 4. Benzo(a)pyrene content of organic extracts of air particulates from indoor and otudoor air in Metro Manila

	Benzo(a)pyrene ug/li of AIR		
		Air	
	Bedroom	*Kitchen*	*Outdoor*
Cainta	1.074 ± 0.01	0.032 ± 0.21	0.123 ± 0.06
Caloocan City	0.123 ± 0.54	0.087 ± 0.14	2.760 ± 0.65
Makati	2.330 ± 0.98	2.760 ± 0.89	0.560 ± 0.23
Malabon	0.632 ± 0.45	0.322 ± 0.13	3.240 ± 0.77
Manila	3.670 ± 0.86	0.670 ± 0.11	4.230 ± 0.09
Marikina	0.145 ± 0.01	0.087 ± 0.11	0.213 ± 0.04
Parañaque	0.078 ± 0.06	0.032 ± 0.05	1.870 ± 0.34
Pasig	4.210 ± 0.78	3.230 ± 0.56	0.070 ± 0.01
Quezon City	3.450 ± 0.56	3.210 ± 0.48	4.740 ± 0.76
Valenzuela	0.087 ± 0.01	0.123 ± 0.04	0.122 ± 0.08

Table 5. Mutagenicity after metabolic activation of personal samples from student commuters to Diliman, Quezon City

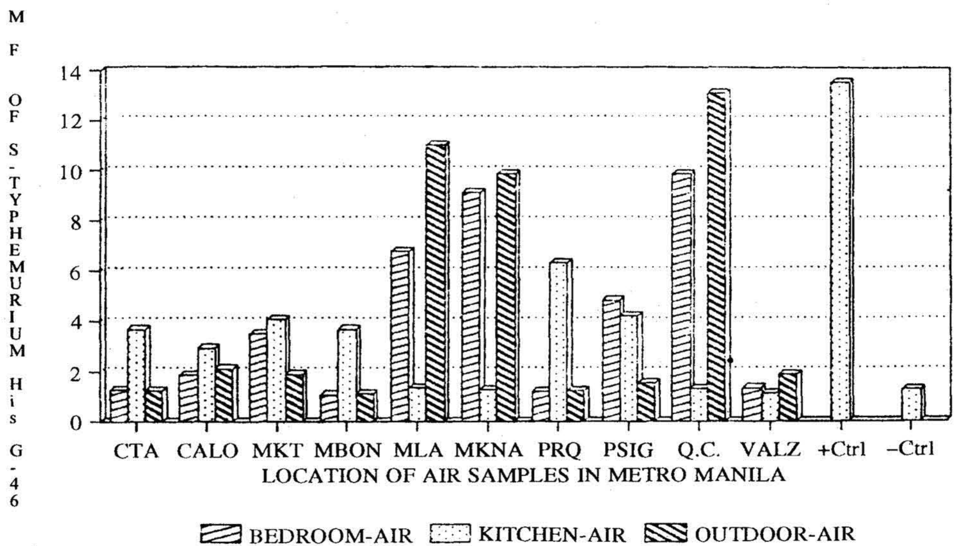
	Mutation Frequency of S-typhimurium His G-46
Positive Control	12.43 ± 1.11
Negative Control	1.06 ± 0.09
Manila from Sta Ana	9.73 ± 0.76
• Malate	14.09 ± 1.22
• Sta Cruz	16.45 ± 1.32
Quezon City from Kamias	10.72 ± 0.96
• La Loma	12.67 ± 1.45
Marikina from Calumpang	10.88 + 1.44
• SSS Village	15.23 ± 1.78
Makati from San Antonio Village	9.25 ± 0.95
• Hilario Street	5.58 ± 0.86
Malabon from Tañong	4.96 ± 0.067
• Burgos Street	6.26 ± 0.85
• Tenejeros	10.84 ± 1.45
Valenzuela from Malinta	6.41 ± 0.98

Table 6. Effects of Benzo(ghi)perylene on the chromosome breaking effects of benzo(a)pyrene, methylcholanthrene and dimethylnitrosamine

	No. of Micronucleated Polychromatic Erythrocytes Per Thousand
Distilled Water	1.67 + 0.15
Benzo(ghi)perylene (BGP) alone	2.02 + 0.69
Benzo(a)pyrene (BAP) alone	10.23 + 1.25
Methylcholanthrene (MC) alone	8.76 + 2.14
Dimethylnitrosamine (DMN) alone	9.56 + 0.98
BGP plus BAP	16.78 + 2.02
BGP plus MC	14.32 + 2.11
BGP plus DMN	15.39 + 1.65

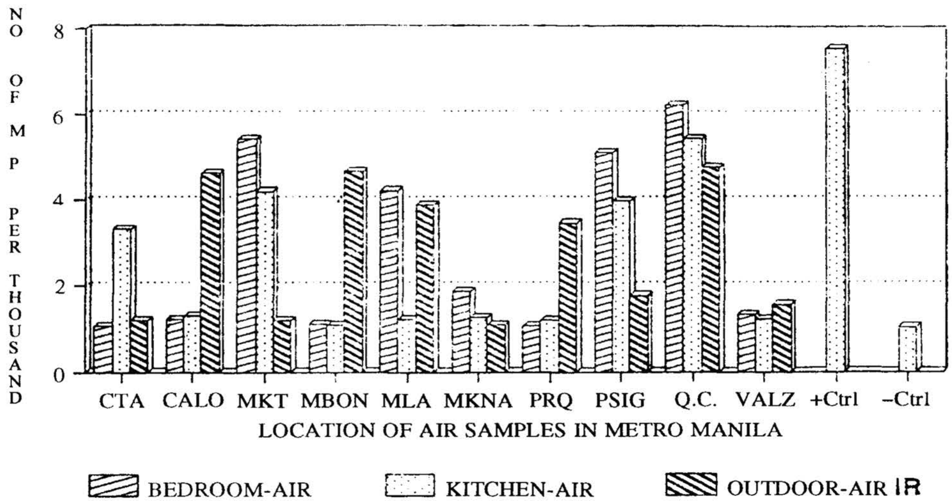
Table 7. Effects of benzo(ghi)perylene on germ cell genotoxicity of benzo(a)pyrene, methylcholanthrene and dimethylnitrosamine

	Percentage Dead Implants
Distilled Water	2.20%
Benzo(ghi)perylene (BGP) alone	2.10%
Benzo(a)pyrene (BAP) alone	28.60%
Methylcholanthrene (MC) alone	31.80%
Dimethylnitrosamine (DMN) alone	42.90%
BGP plus BAP	60.30%
BGP plus MC	59.80%
BGP plus DMN	68.50%



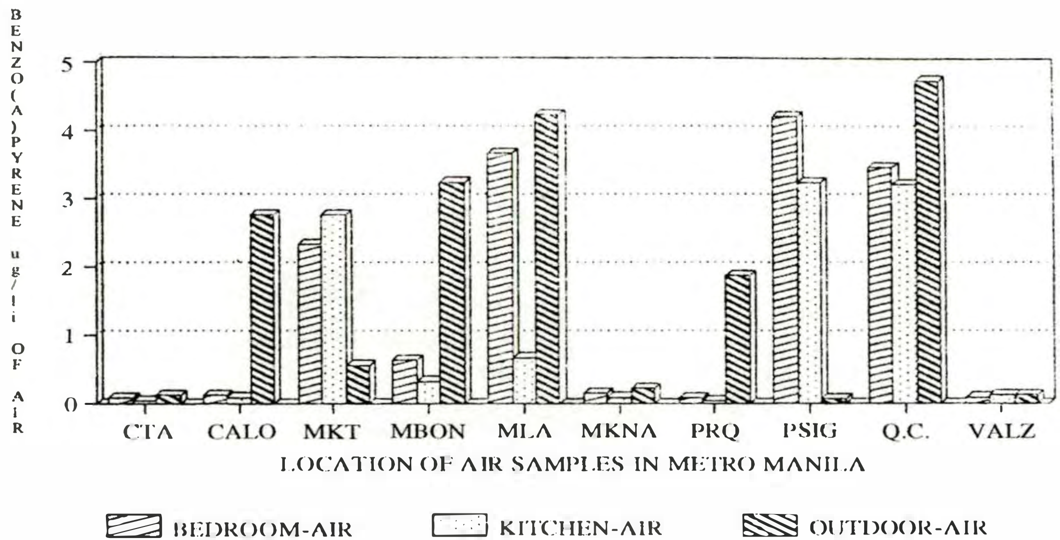
Cta-Cainta; Calo-Caloocan; Mkt-Makati;
Mla-Manila; Mkna-Marikina; Prq-Parañaque
Psig-Pasig; Q.C.; Valz-Valenzuela

Figure 1. Genotoxic activity after metabolic activation of organic extracts of air particulates from indoor and outdoor air.



Cta-Cainta; Calo-Caloocan; Mkt-Makati;
Mbon-Malabon; Mla; Q.C.; Prq-Parañaque;
Mkna-Marikina; Valz-Valenzuela; Psig-Pasig

Figure 2. Chromosome breaking effects of organic extracts of air particulates from indoor and outdoor air in Metro Manila



Cta-Cainta; Calo-Caloocan; Mkt-Makati;
Mbon-Malabon; Mla; Q.C.; Prq-Parañaque;
Psig-Pasig; Valz-Valenzuela; Mkna-Marikina

Figure 3. Benzo(a)pyrene content of organic extracts of air particulates from indoor and outdoor air in Metro Manila

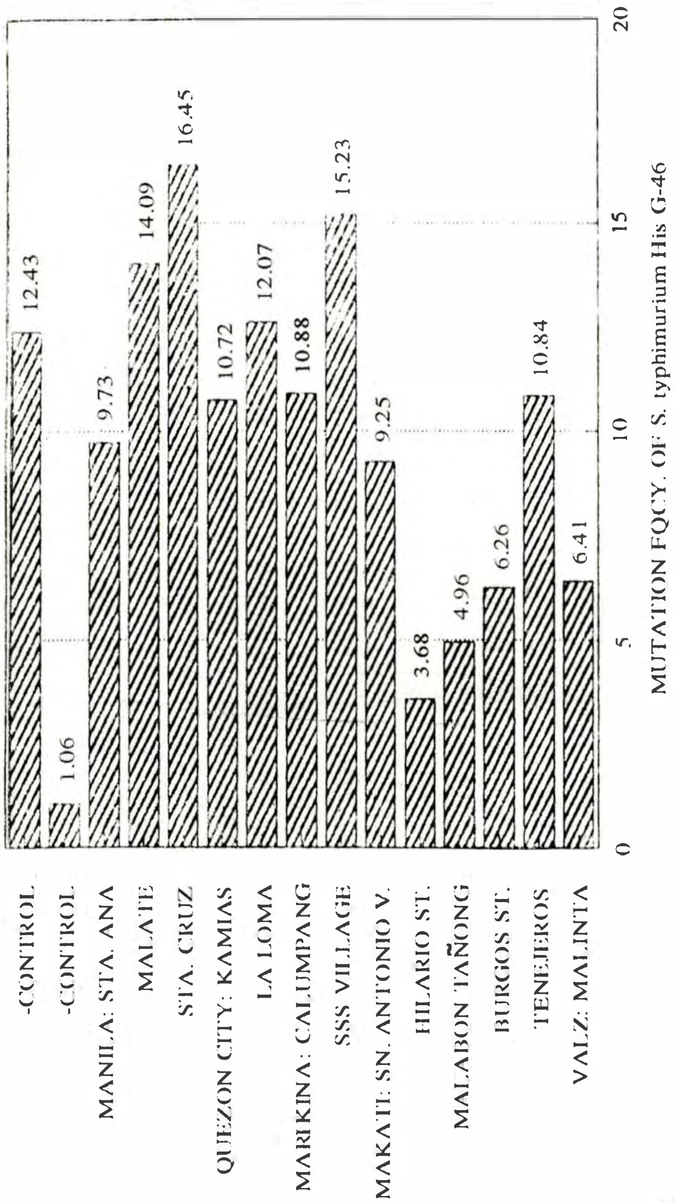
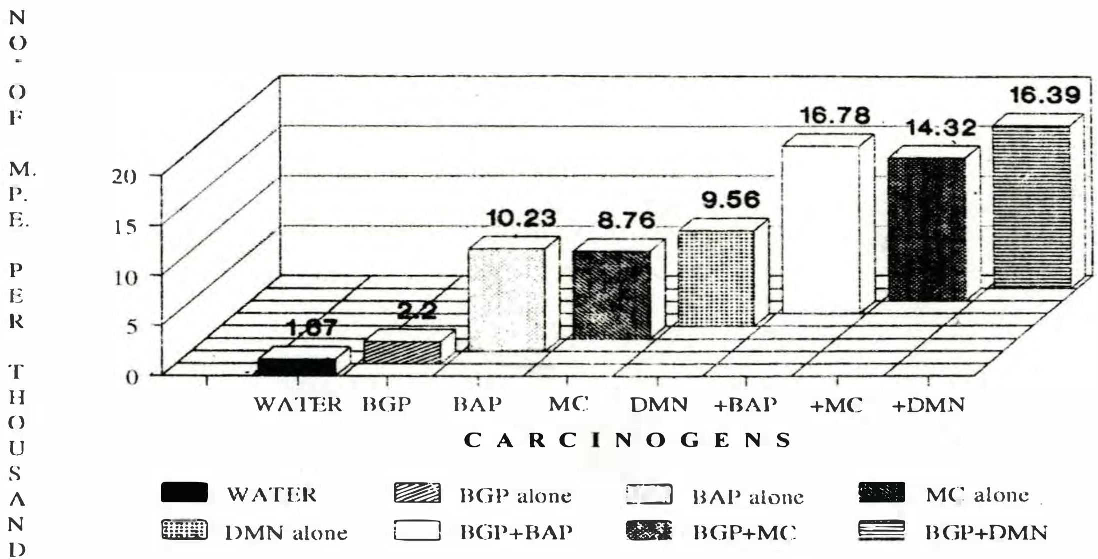
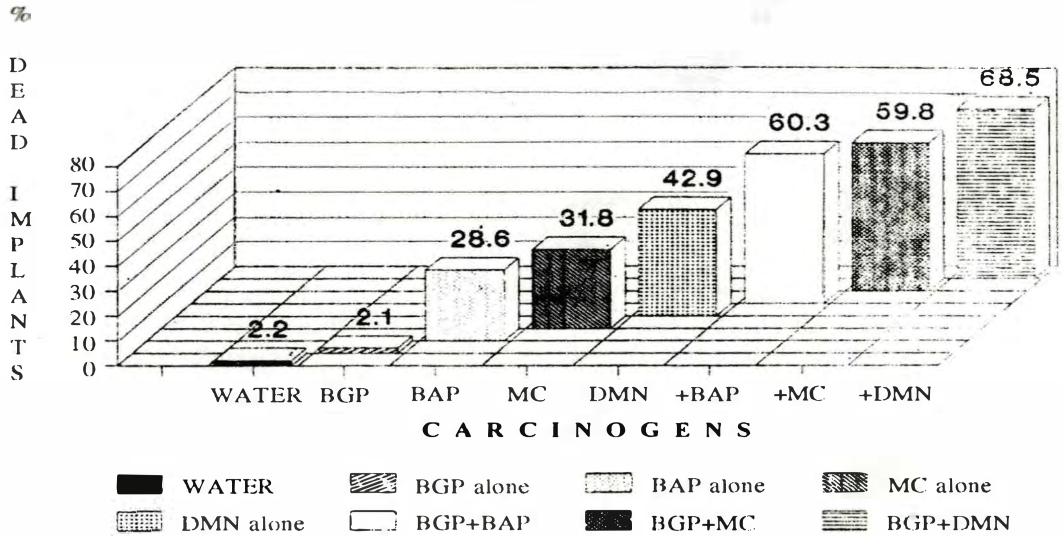


Figure 4. Mutagenicity after metabolic activiation of personal samples from student commuters to Diliman, Q.C.



BAP – Benzo(a)pyrene,
MC – Methylcholanthrene
DMN – Dimethylnitrosamine

Figure 5. Effects of benzo(ghi)perylene on the chromosome breaking effects of BAP, MC and DMN



BAP - Benzo(a)pyrene,
MC - Methylcholanthrene
DMN - Dimethylnitrosamine

Figure 6. Effects of Benzo(ghi)perylene on Germ Cell Genotoxicity of Benzo(a)pyrene, Methylcholanthrene and Dimehtylnitrosamine

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