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WORKPLACE EXPOSURE MONITORING AND MORBIDITY PATTERN OF WORKERS EMPLOYED IN HIGHWAY TOLL PLAZA

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ABSTRACT

At the toll plaza, vehicle operation, including acceleration and deceleration, emit more pollutants and takes longer to cross the area, with the highest level of pollution being generated during this period. As a result, the workers are exposed to numerous sorts of pollution for an extended period of time throughout their workday. In the present study, we monitored probable contaminants inside the toll plaza in order to assess the morbidity conditions of these individuals as a result of chronic exposures at the workplace. Personal measurements of particulate matter (PM), total volatile organic carbons (VOCs) and carbon monoxide (CO), and polyaromatic hydrocarbons (PAHs)-particulate phase were considered to determine exposure. The mean work shift dust concentration of $PM_{2.5}$ and PM_{10} readings were within the permissible level of Indian standards ($PM_{2.5}$ 60 µg/m^3 and PM_{10} 100 µg/m^3) but exceed the WHO recommended guideline ($PM_{2.5}$ 15 µg/m^3 and PM_{10} 45 µg/m^3). The maximum CO concentration was 2.65 ppm, while the lowest was 0.31ppm. Lesser aerodynamic particulate matter of PM_1 and PM_4 and gases, which were monitored, have no recognised standards. H_2S concentrations ranged from 0.06 to 2.00 ppm, while VOC concentrations ranged from 0.08 to 0.41ppm. Total PAHs were found in the range of 2.10-24.81 µg/m^3 and Benzo [α] Pyrene (BaP) was identified in the range of 2.10-7.60 g µg/m^3 in each sample. Headache (66 %), back pain (60.4 %), coughing (54.7 %), hair fall (41.5%), tearing (32.2 %), itching eyes (32.2 %), joint pain (28.3 %), congestion in the nose (17%), sore throat (%), and neck pain (15.1 %) were the most common health problems reported by toll plaza workers.

KEY WORDS : Toll plaza, Workplace exposure, Particulate matter, Polycyclic aromatic Hydrocarbons, Gaseous pollutants, Morbidity pattern

INTRODUCTION

Employees working at the toll plaza were exposed to extended and continuous vehicular emissions pollution. The lack of open space, the limited number of booths and collection cabins, the delayed collection process, and the average waiting time per vehicle all contributed to the higher level of exposure. As a result, toll plazas are likely to be the worst-case situation from automobile emissions occupational exposure. These emissions were a heterogeneous mixture of particulate matter (PM), gases, and volatile air pollutants. In all countries, vehicular pollution is one of the most prevalent sources of air pollution. PM, sulphur oxides (SOx), nitrogen oxides (NOx), lead (Pb), volatile organic compounds (VOCs) and particle-bound polycyclic aromatic hydrocarbons (PAHs), and aldehydes (formaldehyde and acrolein) all were found in significant amounts in air samples collected from both in and out of toll plazas. These pollutants influence surround community and individual health due to increased morbidity and mortality (Sapkota *et al*., 2005; Miriam *et al*., 2015; Reto *et al*.,

2013) Particulate pollution have been linked to a number of risk factors, including chronic obstructive pulmonary disease, oxidative stress, insulin resistance, and endothelial dysfunction (Landrigan *et al.*, 2018; Stafoggia *et al*., 2014; Benziger *et al*., 2016). According to a recent assessment, exposure to gaseous ambient air pollutants is linked to higher morbidity and mortality, with the significant correlations seen in low- and middle-income countries for cardiac respiratory mortality on health outcomes (Newell *et al*., 2018).

All 557 toll plazas in India (as of January 2021, National Highways Authority of India, 2020) are located on various national and state highways, and each toll plaza employs approximately 150 to 200 people who work in three shifts for eight hours each day. Around a hundred thousand people operate at various toll plazas across the country, and there is a shortage of information concerning the exposure evaluation of the workers. To the best of our knowledge, no investigations on the occupational exposures of these people have been undertaken in India. As a result, a study was conducted at a highway toll plaza to describe their exposure to particulate matter, PAHs, and the co-pollutants CO, VOCs, and H_2S inside the cabins, as well as to conduct a self-reported questionnaire-based survey among toll booth workers to assess their health status.

MATERIALS AND METHODS

Study areas

The research was carried out in Bengaluru, India, at toll plazas. All types of vehicles, starting from two-wheelers to oversized vehicles, pass through this toll plaza. The monitoring was performed in each of the 21 cabins, which are manually operated. The cabins were the same size as semi-permanent constructions (5x3.5x7ft^3). The first kinds of cabins include a single window for communication with passengers and a single exit door. It's composed of concrete, with grills and glass shields on the windows. There are no doors in the second sort of cabin. These cabins have the same underground entrance and exit. Metal rods and glass covers were used to grill all four sides.

Monitoring of particulate matter and gaseous pollutants

A real-time data-logging Dust Trak DRX (Model 8533; M/s TSI, USA) was used to gather particle matter within the cabins. To collect PAHs samples, a pre-weighted glass fiber filter paper with a diameter of 37 mm was kept in a cassette with a mesh filter inside the device. Inside each cabin, it ran nonstop for eight hours. The Dust Trak DRX desktop real-time monitor monitored size-segregated mass fraction concentrations for PM_1, $PM_{2.5}$, PM_4, PM_{10}, and Total PM size fractions at the same time. A Run Zero Calibration was performed before to each use and was repeated for each measurement. The levels of several gaseous contaminants such as VOC, CO, and H2S were monitored using the FirstCheck+ Multi Gas Detector (M/s Ion Science, UK). During the sampling period, the levels of these gases within the toll plaza cabins were checked every 10-minute interval for 1 minute.

Estimation of the particle bounded PAHs

The air samples collected on filter sheets were extracted in an ultrasonic bath for 60 minutes at room temperature with acetonitrile. A rotary evaporator is subsequently used to concentrate the extracted solute. Before HPLC-FLD analysis, all samples were filtered via a syringe filter (0.45 m Millipore PTFE filters) (NIOSH, 1998; Sen *et al*. 2018). The PAH molecule chosen for study had two to six rings (molecular weights ranging from 128 to 278). All of the samples were tested for a total of sixteen PAHs at the same time. PAH compounds, namely Naphthalene (NAP), Acenaphthylene (ACPy), Acenaphthene (ACE), Fluorene (FLU), Phenanthrene (PHE), Anthracene (ANT), Fluoranthene (FLA), Pyrene (PYR), Benzo(α)anthracene (BaA), Chrysene (CHR), Benzo[b]fluoranthene (BbF), Benzo[k]fluoranthene (BkF), BaP, Dibenzo [á h] Anthracene (DahA), Benzo[ghi]perylene (BghiP) and Indeno(1,2,3-cd) pyrene (IND) have been analysed. An aliquot (20 µl) of sample was injected into an HPLC system equipped with a fluorescence detector (FLD) and a C18 reversed phase column (250mm x 4.6 nm, 5 µm). A solvent gradient of acetonitrile and deionized water was utilized, with a linear gradient from 60% acetonitrile/ 40% deionized water to 100% acetonitrile at 1.5 ml/min for 50 minutes. An external standard was used to calibrate the HPLC equipment. Calibration and quantification were performed using a Sigma Aldrich standard mixture containing 16 PAHs. The excitation and emission wavelengths of a fluorescence detector were adjusted to 340 nm and 425 nm, respectively. To ensure laboratory quality control, procedure blanks, spiked blanks, matrix spikes, and sample duplicates were analysed.

For each phase of sampling, a field blank was obtained and blank correction was conducted. By serially diluting known working standards and evaluating them on the device to a signal-to-noise (S/N) ratio of 3, the detection limit was determined. By duplicating the analysis of a spiking known concentration of standard PAH chemicals with the filtered sample, the method's recovery efficiency was assessed. The majority of the compounds had good recovery rates, with mean values ranging from 75 to 90 percent. After every eight to ten unknown samples, domestically prepared standard samples were run.

Personal data assessment

Personal interviews were conducted with the toll plaza workers based on a pre-designed questionnaire to collect details. The questionnaire consisted of five divisions, with the most important being demographic information, experience, personal habits and diet, concerns about the workplace and about their health problems. A total of 81 subjects participated in the questionnaire survey, out of which 53 were toll collectors and the rest were other supporting staff, such as lane supervisor, shift-in-charge, cleaners, toll manager, security and electrical supervisor, and so on.

RESULTS AND DISCUSSION

Particulate matter exposure

Table 1 demonstrates the levels of pollution exposure in all 21 cabins at the toll plaza, including PM_1, $PM_{2.5}$, PM_4, PM_{10} and total PM, particle phase PAHs, CO, H2S, and VOCs. When compared to Indian norms ($PM_{2.5}$ 60 µg/m^3 and PM_{10} 100 µg/m^3), the results show that mean $PM_{2.5}$ and PM_{10} values are within permitted limits. For 24-hour sample, the mean $PM_{2.5}$ and PM_{10} levels surpassed the WHO recommended range ($PM_{2.5}$ was 25 µg/m^3 and PM_{10} was 20 µg/m^3). Toxic gases such as CO, H2S, and VOCs were monitored using the First Check+ Multi gas detector. The maximum CO concentration was 2.65 ppm, while the lowest was 0.31 ppm. The maximum CO concentration was 2.65 ppm, while the lowest was 0.31ppm. H2S concentrations ranged from 0.06 to 2.00 ppm, while VOC concentrations ranged from 0.08 to 0.41 ppm.

Figure 1 illustrates the individual and cumulative concentrations of particulate matter (PM_1, $PM_{2.5}$, PM_4, PM_{10} and TSPM) inside the cabins (a-e). Figures 1a, 1b, and 1c show that the lowest concentrations of PM_1, $PM_{2.5}$, and PM_4 are found inside cabin S-9 (PM_1:21 µg/m^3; $PM_{2.5}$:26 µg/m^3 and PM_4:32 µg/m^3, respectively), whereas the greatest concentration is found in cabin S-3 (PM_{1102} µg/m^3; $PM_{2.5}$:109 µg/m^3 and PM_4:121 µg/m^3). The concentration of PM_{10} in all 21 cabins where the work was done is depicted in Figure 1d. Getting into cabin-6 (52 µg/m^3) had the lowest concentration in this scenario. This cabin is only for POS (Point of Sale), which means it is a cabin that sells monthly passes. This lane has a lower number of vehicles stopping to pay tolls on a daily basis than other lanes. This cabin is only for POS (Point of Sale), which means it is a cabin that sells monthly passes. This lane has a lower number of vehicles stopping to pay tolls on a daily basis than other lanes. The highest concentration was found in the Airport Toll Plaza's compartment S-12 (182 µg/m^3). In addition, PM_{10} concentrations in cabins S-1 (103 µg/m^3) and S-2 (124 µg/m^3) exceeded the CPCB limit of 100 µg/

Table 1. Summary of the Particulate Matter, PAHs (µg/m^3) and Gaseous (ppm) Pollutants in all the Cabins

Parameter	Mean±SE	Median	Range	Percentiles				P-Value
				25	50	75	95	
TSPM	127±11	111	70-271	94	111	140	268	*0.083*
PM_{10}	90±8	78	52-182	65	78	97	181	*0.008**
PM_4	58±5	48	32-121	43	48	73	118	*0.504*
$PM_{2.5}$	49±5	42	26-109	37	42	64	106	*0.740*
PM_1	44±5	37	21-102	34	37	57	99	*0.504*
PAHs	5.67±0.07	4.31	2.10-12.81	3.29	4.31	7.45	12.73	*0.260**
CO	0.69±0.17	0.31	0.08-2.74	0.11	0.31	1.39	2.65	*0.260**
H_2S	0.26±0.09	0.16	0.06-2.00	0.09	0.16	0.29	1.84	*0.007**
VOCs	0.22±0.02	0.23	0.08-0.41	0.14	0.23	0.29	0.40	*0.026**

*Significant level is 0.05

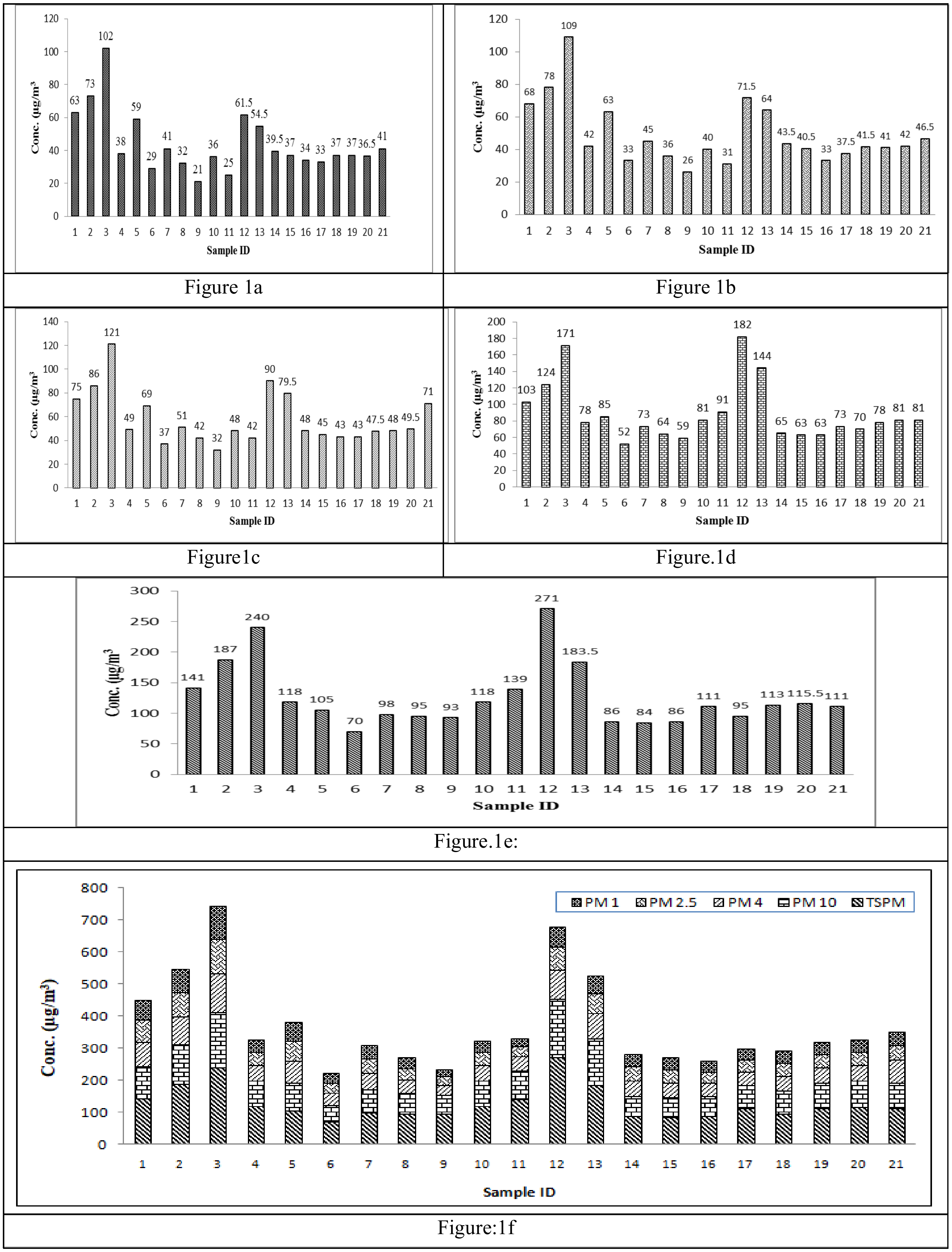

Figure 1(a-f): Concentration of PM_1 (1a); $PM_{2.5}$ (1b); PM_4(1c); PM_{10} (1d); TSPM(1e) and Cumulative Concentration of particulate matter (PM1, PM2.5, PM4, PM10 and TSPM) inside cabins m^3. The lowest TSPM concentration was in cabin S-6 (70 µg/m^3), which is the cabin for the monthly pass issue counter, and the highest was in cabin S-12 (271 µg/m^3), as shown in Figure 1e.

Chen *et al.* (2007) measured CO, NO_2, total hydrocarbons, and PM_{10} at four highway toll gates in Chongqing, China, in June and July 2003. Indoor PM10 concentrations averaged 217 µg/m^3 over a one-hour period. They also discovered that CO, PM_{10}, and NO_2 had significant correlations at the 0.01 level, and that traffic flow had a substantial association with NO_2, total hydrocarbons and PM_{10}. The average PM_{10} level in this study was substantially lower than the one-hour average level in Chongqing, and there was no significant association between PM and other gases (Table 2). Different size fractions of particulate matter and PAHs were shown to have a significant association. $PM_{2.5}$ values above the national permissible limit (60 µg/m^3) and were also higher than the current study ($PM_{2.5}$ level 49.0 µg/m^3), according to air quality monitoring ($PM_{2.5}$, CO in Delhi urban, India) (Sehgal *et al.*, 2014). Cheng and Li YS examined the levels of ultrafine particles (UFPs) and their size distributions on a highway electronic toll collection (ETC) lane (2011). The average UFP levels in the highway ETC lane were 5–10 times higher than in the city, indicating that a large proportion of UFPs flew out of cars at the toll Plaza. Ismail *et al.* did a study in which they found that (2011) PM_{10} and $PM_{2.5}$ levels were 10.6–208.4 µg/m^3 and 6.6–187.9 µg/m^3, respectively, in comparison to the current study, when PM_{10} levels were 52-182 µg/m^3 and $PM_{2.5}$ levels were 26-109 µg/m^3.

PAHs exposure

The particle phase PAHs concentrated in the dust was quantified using the collected exposed filter sheets. Table 3 shows the mean concentrations of the thirteen PAHs constituents in 21 samples, together with a range of variance. Figure 2 depicts the individual values of each PAH acquired from each cabin, with BaP being identified in each sample.

Table 3. Range of concentration of PAHs compounds analyzed.

PAH compound	Mean (µg/m^3)	Range (µg/m^3)
NAP	0.18	BDL- 0.96
ACPy	0.79	BDL- 0.79
ACP	0.11	BDL- 0.79
FLU	00.22	BDL- 1.12
PHE	0.28	BDL- 1.91
ANT	0.33	BDL- 2.24
FLY	0.08	BDL- 2.23
PYR	0.40	BDL- 0.45
B(a) A	0.14	BDL- 2.96
CHR	0.04	BDL- 0.84
B(a)F	0.06	BDL- 0.66
B(k)F	0.06	BDL- 0.53
B(a)P	3.69	2.10-7.60
Total PAHs	5.67	2.10- 12.81

Cabins 9 (S-17: 2.10 µg/m^3) and 15 (S-5: 7.60 µg/m^3) had the lowest and highest BaP levels, respectively. Cabins 9 (S-16: 2.10 µg/m^3) and 18 (S-1: 24.81 µg/m^3) have the lowest and highest T. PAHs values, respectively. These readings were substantially higher than WHO's recommended value for ambient air PAHs of 1ng/m^3 (0.001 µg/m^3) (WHO-Euro 1987). However, when compared to other agencies' requirements, they all fall within acceptable bounds. Only the PAHs absorbed into the filter paper are included in the total PAHs assessed in this study. The PAHs in the gaseous phase was not measured. It's possible that this contributed to the study's lower results. Quantification of PAH in the gaseous phase will require more research.

Susan *et al.* (2005) conducted research on the

Table 2. Pearson Correlation among the Particulate Matter, PAHs and Gaseous Pollutants

	TSPM	PM_{10}	PM_4	$PM_{2.5}$	PM_1	PAHs	CO	H_2S	VOCs
TSPM	1.00	.986**	.852**	.804**	.759**	.475*	-0.41	0.06	-.477*
PM_{10}	.986**	1.00	.896**	.850**	.806**	.482*	-0.37	0.08	-.473*
PM_4	.852**	.896**	1.00	.976**	.961**	.622**	-0.30	0.28	-.461*
$PM_{2.5}$	.804**	.850**	.976**	1.00	.995**	.709**	-0.24	0.13	-.462*
PM_1	.759**	.806**	.961**	.995**	1.00	.722**	-0.22	0.12	-.455*
PAHs	.475*	.482*	.622**	.709**	.722**	1.00	-0.40	-0.04	-0.31
CO	-0.41	-0.37	-0.30	-0.24	-0.22	-0.40	1.00	-0.16	0.13
H_2S	0.06	0.08	0.28	0.13	0.12	-0.04	-0.16	1.00	0.02
VOCs	-.477*	-.473*	-.461*	-.462*	-.455*	-0.31	0.13	0.02	1.00

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

prevalence of polycyclic aromatic PAHs in soot deposited near the Mariannhill toll plaza on the N3 motorway in KwaZulu-Natal, South Africa. A number of PAHs were discovered, including BaP, FLA, CHR, BaA, and BghiP, some of which are known carcinogens. We also discovered thirteen PAHs compounds in this investigation, out of the sixteen priority PAHs listed by the USEPA. Tsai *et al.* (2002) used direct and indirect methodologies to examine the levels of polycyclic aromatic hydrocarbons (PAHs) in three types of toll plazas at a highway toll station. The PAH distributions for samples obtained from the car lane/ticket-payment and car lane/cash-payment toll plazas showed no significant difference, although both were considerably different from those collected from the bus/truck lane toll plaza. The above results could be attributable to the fact that the first two types of toll plazas were built for the same sort of traffic (cars and vans), whilst the third was built for a different type of traffic (trucks) (i.e., buses and trucks). The total-PAH content found during the day shift was not statistically different from that found during the night shift for any given kind of toll plaza, but both were significantly greater than that found during the late-night shift for any given type of toll plaza. They discovered carcinogenic total-PAHs in the following order during every given work shift: bus/truck lane > car lane/ticket-payment > car lane/cash-payment. It is determined that assessing PAH concentration in various types of toll plazas using vehicle flow rate is an effective indirect method.

In Spain, Miriam *et al.* (2015) conducted personal sampling for all attendants on the day shift, testing for three classes of chemical substances: PAHs, VOCs, and aldehydes (formaldehyde and acrolein). There were no significant connections between exposure levels and the number of cars. Furthermore, there were no variations between truck and car lanes, or between within and outside the toll Plaza. Some of the observed VOCs were

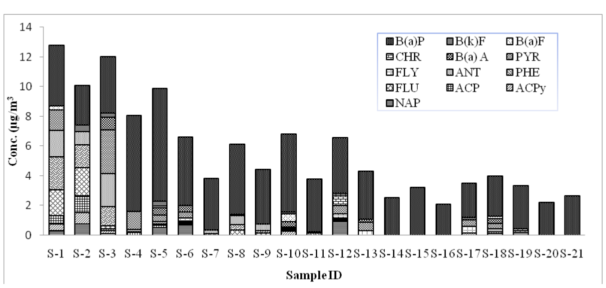

Fig. 2. Cumulative Concentration of different PAHs compounds inside the toll plaza

consistent with the usage of cleaning chemicals and were not related to vehicle exhaust. The amounts tested were well below the defined occupational exposure limits, but they were often greater than those reported for outdoor urban areas.

Personal data analysis and health status outcome

A questionnaire-based study was done among toll Plaza employees to better understand their personal health state in relation to their work experience. A total of 81 people were surveyed, with 53 of them being toll collectors. Toll collectors just operate inside the cabins and collect the tolls. Supporting workers can be found on the road or in the office, or sometimes both. Except for the cleaning crew, everyone who works at the toll plaza is a man. Name, age, sex, height, weight, educational qualifications, and marital status were among the personal facts. The bulk of toll collectors are between the ages of 18 and 23, accounting for 50.9 percent, while the following age group, 24-29, accounts for 60.7 percent (Table 4). The average age of 53 toll collectors is 24.09 years, with an average of 1.73 years of experience. The average age of the other supporting employees was 30.61, and their experience ranged from one to seven years. Workers at the toll plaza have earned a bachelor's degree or a diploma in a variety of areas. In the toll plaza, there are three shifts, each of which lasts for eight hours. The number of night shifts per month is set at ten. Personal protection equipment (PPE) was not worn by any of the 53 personnel at the toll plaza. Eight other workers in the supporting category used safety equipment (only masks) on occasion. Exercise was done by 15.1 percent of toll plaza employees, smoking by 7.5 percent, chewing tobacco by 7.5 percent, consuming alcohol by 32.1 percent, eating non-vegetarian food by 98.1 percent, and drinking tea or coffee by 84.9 percent.

Self-reported health problems were also included in the current study, with the most common being headache (66%), back pain (60.4%), coughing (54.7%), hair fall (41.5%), tearing (32.2%), itching eyes (32.2%), joint pain (28.3%), congestion in the nose (17%), sore throat (17%), neck pain (15.1%), and so on. The tollbooth employees have acknowledged that they face these issues either during or after their shift. Headaches, coughing, itchy eyes, and other ailments reported by the other supporting workers. The main concerns they had about their workplace were (I) they had to deal with extreme weather, (ii) the air inside the cabin was stuffy due to poor ventilation, (iii) they all complained about too much physical hazards, (iv) too much dust released from heavy vehicular exhaust, (v) they were not provided with any personal protective equipment, and (vi) they had to deal with harassment every day (v) They are not equipped with PPE (vi) they are subjected to hostile reactions from travellers on a daily basis, and (vii) they have workplace hazards. No one at the toll plaza was happy with the seating arrangement and expressed their dissatisfaction. A study of highway toll plaza workers found that persons who were exposed had an increased number of acute irritating symptoms like headaches, nasal congestion, eye irritation, and dry throat (Huang *et al.*, 2007). Because of poor air quality produced by pollution from car exhaust, the incidence of upper respiratory tract infections among toll plaza workers is higher than that of other people (Jie *et al.*, 2011). Yang *et al.*, (2002) observed that questionnaires were used to evaluate the prevalence of respiratory and other health problems among highway toll booth workers. A high prevalence of central nervous system complaints (headaches, irritability or anxiety, and unusual exhaustion) was reported in a small proportion of responders (43.2%), as was a high prevalence of

Table 4. Demographic details of study group and their morbidity pattern

Variable		Toll Collectors	Others
Age Group (in year)			
	18-23	27(50.9)	4(14.3)
	24-29	22(41.5)	17(60.7)
	≥30	4(7.5)	7(25.0)
	Total	53	28
	Average Age	24.09	30.61
AVG. Height (in cm)	167.81	168.64	
AVG. Weight (in Kg)		55.98	65.89
AVG. Experience (in yrs)		1.73	3.44
Marital Status	Married	47(88.7)	17(60.7)
Education	Unmarried	6(11.3)	11(39.3)
	Illiterate	1(1.9)	2(7.1)
	Below 10th	2(3.8)	5(17.9)
	10th & PUC	14(26.4)	6(21.4)
	Diploma & Degree	36(67.9)	14(50.0)
	Post Graduation	0	1(3.6)
Personal Habit	Doing Exercise	8(15.1)	9(32.1)
	Smokers	4(7.5)	8(28.6)
	Tobacco Chewers	4(7.5)	2(7.1)
	Alcohol Consumers	17(32.1)	12(42.9)
	Having Non-Veg. food items	52(98.1)	27(96.4)
	Drinking Tea/ Coffee	45(84.9)	25(89.3)
	PPE	Nil	8(28.5)
Health Complaints	Headache	35(66.0)	17(60.7)
	Back pain	32(60.4)	6(21.4)
	Coughing	29(54.7)	15(53.6)
	Hair fall	22(41.5)	9(32.1)
	Tearing	16(30.2)	8(28.6)
	Itching eyes	16(30.2)	12(42.9)
	Joint pain	15(28.3)	6(21.4)
	Congestion in nose	9(17.0)	6(21.4)
	Sore throat	9(17.0)	8(28.6)
	Neck Pain	8(15.1)	2(7.1)
	Whistling Chest	4(7.5)	6(21.4)
	Unusual tiredness	4(7.5)	4(14.3)
	Anxiety/Irritability	2(3.8)	3(10.7)
	Berating difficulty	1(1.9)	7(25.0)
	Skin allergies	0	1(3.6)

Values in parenthesis expressed are %

mucous membrane irritation (eye irritation, nasal congestion, and dry throat), and musculoskeletal difficulties (joint and back pain). These symptoms are a result of the acute irritant and central nervous system consequences of motor vehicle exhaust exposure. The musculoskeletal issues are most likely the results of bending, reaching, and leaning out of the toll booth.

CONCLUSION

The Central Pollution Control Board, India's environmental regulatory agency, has set limitations for particulate matter concentrations inside several cabins, which have been surpassed. Despite the fact that the PAH content was within NIOSH and ACGIH guidelines, the workplace exposure was a contest. The quantity of hazardous gases inside the cabins was not considerable, according to the monitoring.

According to their personal health evaluation, they were experiencing back pain and neck pain symptoms as a result of their body posture. We also saw that they were suffering from a headache and lung congestion as a result of their constant exposure to occupational risks.It's possible that their hair loss is dủe to their exposure to automotive pollution in a humid work environment. In this sort of occupation, biological monitoring and in-depth study of the ventilation systems, as well as the ergonomics and workplace stresses of working at toll booths, are required. Fuel wasting was also a concern as a result of traffic congestion.Before the mandated adoption of electronic devices (FASTag) on all toll booths, the current study was conducted in a small number of toll plazas. A fresh data set with a larger number of toll plazas can be acquired with electronic toll collection over toll booths in the future work of the study, and the findings can be compared with the results of this study.

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