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MONITORING OF TOTAL SUSPENDED AIR PARTICULATE IN THE AMBIENT AIR OF WELDING, CAR PAINTING AND BATTERY CHARGING WORKSHOPS IN ILE-IFE NIGERIA

V. C. IKAMAISE, I. B. OBIOH, I. E. OFOEZIE and F. A. AKEREDOLU

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ABSTRACT

This study was carried out to determine the concentration of total suspended particulate matter (TSP) in the ambient air of selected small-scale industrial workshops in Ile-Ife – battery charging and repairs (BCR), vehicle spray-painting (VSP) and welding and panel beating (WPB). A total number of 30 workshops; 10 from each group of small-scale industries (SSI) in Ile-Ife were selected for the investigation. A control site was also selected. Samples of particulate matter were collected by gravimetric method within each workshop environment and the control site. The mean TSP concentration in the workshops ranged from 590 $\mu g/m^3$ in VSP to 930$\mu g/m^3$ in BCR, and from 313$\mu g/m^3$ in BCR to 590$\mu g/m^3$ in VSP for dry and wet seasons respectively. The seasonal trend of TSP concentration in the workshops was BCR>WPB>VSP for dry season and VSP>WPB>BCR for wet season. Significant differences between TSP concentration in the workshops and the control site were obtained. TSP concentrations in workshops exceeded both WHO and FEPA threshold limit for clean air. SSI activities are therefore a source of environmental air contamination.

KEY WORDS:Small-Scale Industries, Particulate Matter, Air Quality, and Contamination.

INTRODUCTION

Apart from water, food and soil, air quality is an important factor determining the sustainability of the environment. The level of TSP load is often used to assess air quality. Airborne particulate matter is an ensemble of solid and liquid particles suspended and dispersed in air (UNEP/WHO, 1994). Air pollutants permeate all fabric of environment through biogeochemical routes. These may constitute contaminants or pollutants when present in greater than recommended concentrations as a result of man-made activities. They also have a net detrimental effect upon the environment or upon something of value in the environment (Manahan, 1991). The severity of contamination by pollutants increases with emission source strengths and the atmospheric mixing of the pollutants (Obioh et al, 1993).

Both natural and man-made activities serve as sources of air contamination in rural as well as urban centres. Sources of pollution in urban areas are generally related to important human activities aimed at improving the quality of life which may be industrial, transportation, domestic, institutional and commercial activities. Industrial activities implicated in environmental contamination include oil refining, metals smelting, food processing, wood processing, metal recycling, mining, painting, battery making, plumbing, dye fabrication, welding, brass work, foundry work, pottery work, and news print, (DHSS,1980; Ward, 1988; Akeredolu, 1989; Oyedele, et al. 1995)

Human health is commonly affected by damage done to body organs and tissues as a result of absorption of the respirable portion of TSP, which contain heavy metals and trace elements. The associated health problems may be cough, asthma, learning disability, loss of vision, anemia, renal failure, and infertility. (Cohen, et al, 1973; Lovejoy and Linden, 1991; Baranski, 1993; Sullivan, 1993).

Although studies on environmental impact of particulate matter suggest that urban dwellers in highly industrialized countries are exposed to higher than recommended levels of contamination (Cohen *et al.*, 1973), the incidence of associated health problems are not limited to urban dwellers in highly industrialized towns. Bearing in mind other etiological factors to these problems, contribution from TSP contamination of less industrialized urban centres and towns need to be elucidated.

In Nigeria, information on environmental pollution by particulate matter and their impacts on human health are largely insufficient. Where available, they are targeted at larger industries and vehicular emissions (Ndiokwere, 1984; Asubiojo et al, 1991; Oyedele *et al.*, 1995). With

V. C. IKAMAISE, Radiology Department , College of Medical Sciences, University of Calabar, Calabar, Nigeria.
I. B. OBIOH, Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria
I. E. OFOEZIE, Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife, Nigeria
F. A. AKEREDOLU, Department of Chemical Engineering Obafemi Awolowo University, Ile-Ife, Nigeria

the growing air pollution problems in Nigeria due to the rate of urbanization resulting in the concentration of SSI in semi-urban towns, workers and the general public may be exposed to increased concentration of TSP and the associated health problems. It is important and timely that the associated risks of TSP contamination from activities of SSI in semi-urban centres are investigated. This study was therefore carried out in Ile-Ife, a semi-urban town in the South Western Nigeria, to assess the extent to which the environment is contaminated by TSP emanating from SSI.

METHODOLOGY

Workshops environment and activities

All investigated workshops were located on the roadside within Ile-Ife town (Figure 1). The Battery charging and repairs (BCR) workshops were small huts constructed with mud bricks. Only a few of these workshops had windows for free circulation of air. The huts were either attached to larger residential buildings or to other commercial houses within the town. Solid and liquid wastes from these workshops were usually disposed freely around the workshop premises. Activities include replacement of discharged battery electrolyte and recharging of such battery using battery chargers, as well as replacement of cells and rebuilding of damaged batteries.

Vehicle painting workshops (VSP) are isolated from other buildings and are much larger than the battery charging workshops. They are closed buildings with only one large outlet, large enough to take in cars and buses. None of the workshops investigated had chimneys or other devices for regulating aerosol paints released from the spray jets. Aerosol paints were therefore freely released to the atmosphere. In addition, paint scrapings (wet and dry) were freely disposed within the vicinity of the workshops. Daily routine starts with preparing vehicles for spraying. The preparation of vehicle for spray-painting involves either wet or dry scraping of the old coat of paints. Dry scraping gives rise to a direct release of paint-dust to the atmosphere while in wet scraping, most of the old coat of paint is washed off to the soil. Spraying is normally done using spray jet. In some instances the workers wear protective gadgets during spraying activities to prevent inhalation of aerosol paints. But this safety requirement is often violated in most cases.

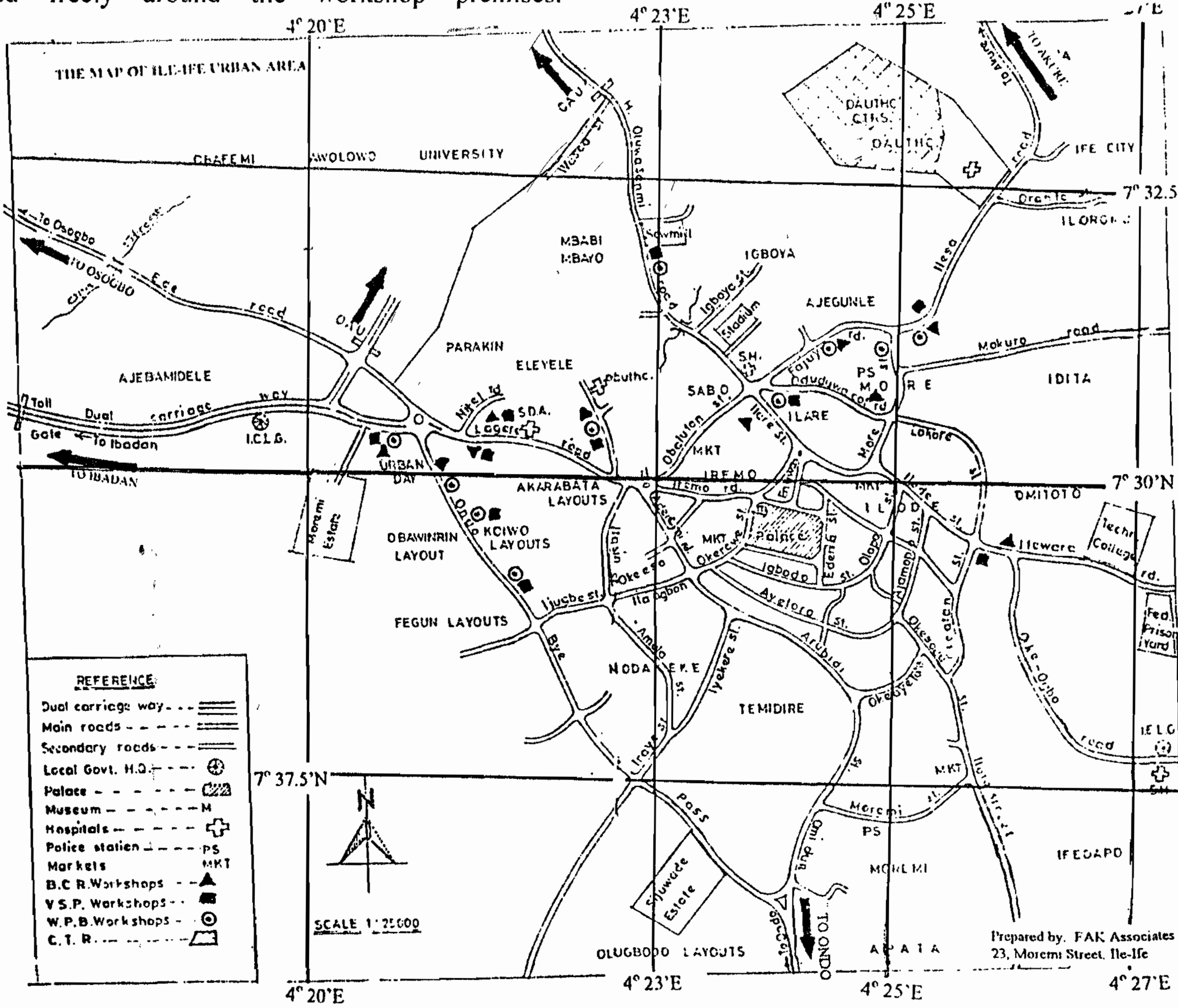

Figure 1. The Map of Ile-Ife Urban Showing Sampling Sites

The welding workshops (WPB) usually consist of a small hut and a large open space where most welding activities take place. Scrap metal parts and pieces were freely disposed around the workshop premises. Activities include cutting and welding works. Metal cutting is usually performed using metal saws, but in some rare cases, electric chisels were used. These activities emit metal dust into the atmosphere. Pieces of unused metals are also disposed indiscriminately around the workshop premises. Electric arc or oxy-acetylene welding method may be employed. In either case, electrodes are used to join two contiguous edges of metal parts together. Welding activities release particulate matter and heat energy into the atmosphere, as well as result in indiscriminate disposal of slated lime from calcium carbide around the workshop premises.

The control site was far removed from all the small-scale industrial workshops in the town. It is located within the senior staff residential quarters of Obafemi Awolowo University Teaching Hospital where none of the activities investigated takes place (Figure 1). It was therefore assumed that air contamination from industrial activities within and outside the hospital would not significantly affect the control site environment.

Ambient Air Sampling

Particulate matter collection was carried out in the months of January and February for dry season and, June and July for wet season. Ten workshops from each group of target SSI were randomly selected (a total of 30 workshops). That is 10 from 90 battery charging and repairs workshops, 10 from 65-vehicle spray painting and 10 from 60-welding/Panel beating workshops in Ile-Ife urban.

Airborne particulate matter was collected on whatman filters using a portable AZTEC AS820 twin flow gravimetric high volume air sampler. The sampler was placed on a tripod 1.5m high. The sampling unit consisted of a gas pump, a filter-holder-manifold connected to the sampling pump by a teflon tube. A gas flow rate meter with a rating of 0-12 L/min was used to measure the flow rate during sampling, which varied between 10-12 L/min. Before sampling, all unloaded filters were dried in a desiccator for at least 48 hours at room temperature and their initial weights were taken (W_0). After sampling, the loaded filters were again desiccated and re-weighed (W_1) to determine the weight of total TSP, which is equivalent to the weight difference between the initial and final weights of the filter ($W_0 - W_1$). The choice of duration and temperature for drying the filters was to ensure that constant weights of the filters are obtained to avoid introduction of error to the weight of collected particulate matter, (Oluyemi, 1996). The TSP was then determined by the ratio of weight of collected particulate to the volume of sampled air.

$$TSP = \frac{W_p}{V_{AIR}}$$

*Where **TSP** is the total suspended particulate matter ($\mu g/m^3$), W_p is the weight of collectedparticulate and V_{air} is the air volume sampled.*

$$Wp = W_1 - W_0$$

Where W_1 is the weight of loaded filter and W_0 is the weight of unloaded filter

$$Vair = Fr \times St$$

*Where **Fr** is the flow rate and **St** is the sampling time*

The duration for collection of each sample was 6 -8 hours (Ogunsola et al, 1994; UNEP/WHO, 1994b).

Statistical Analysis

Range and mean concentration of TSP in various workshops were computed. Comparative bar charts were plotted to show seasonal variation and exceedence of international and national air quality guidelines. Student's t test was performed to demonstrate the level of significance in TSP concentrations between the seasons and between workshops and the control site.

RESULTS AND DISCUSSION

The range and mean values of TSP concentration in the ambient air of investigated workshops and control site is presented in table 1. Table 2 shows the seasonal variation, while table 3 shows the difference between concentrations in workshops and the control site. Table 4, presents record on some TSP analysis carried out in various parts of Nigeria.

The concentration of TSP in the various workshops followed a clear seasonal trend. The dry season TSP concentration was in the order BCR>WPB>VSP; while the wet season concentration followed a reverse trend: VSP>WPB>BCR (table 1.).

Table 1.Range and mean concentration of TSP in the ambient air of selected workshops and control site in Ile-Ife ($\mu g/m^3$)

	DRY SEASON		WET SEASON	
SSI	RANGE	MEAN	RANGE	MEAN
BCR	650-1135	930±160	230-417	313±60
WPB	485-1480	880±120	270-440	360±70
VSP	440-740	590±260	460-850	590±120
CTR	90-250	170±50	60-250	150±60

Table 2. Variation in seasonal concentration of TSP in the ambient air of selected workshops in Ile-Ife (μg/m³)

SSI	MEAN CONCENTRATION OF TSP DRY	WET	t - value	Significant
BCR	930±160	313±60	9.86	0.001
WPB	880±120	360±70	5.96	0.001
VSP	590±260	590±120	0.46	Not significant
CTR	170±50	150±60	1.0	Not significant

Table 3. Comparison of TSP concentration between workshops and the control site in Ile-Ife

SSI	SEASON	MEAN CONCENTRATION OF TSP WORKSHOPS	CONTROL SITE	t - value	Significant
BCR	Dry	930±160	170±50	11.31	0.001
	Wet	313±60	150±60	5.18	0.001
WPB	Dry	880±120	170±50	8.64	0.001
	Wet	360±70	150±60	6.38	0.001
VSP	Dry	590±260	170±50	8.41	0.001
	Wet	590±120	150±60	12.41	0.001

The dry season concentrations within BCR and WPB workshops were significantly higher than the wet season concentration, while comparable seasonal concentrations were obtained within VSP workshops and the control site (table 2.). TSP concentrations in all investigated workshops were significantly higher than that obtained at the control site during both seasons. Figure 2 graphically shows these seasonal trends in comparison with the world limitation guidelines recommended by the World Health Organization (WHO), and the Federal Environmental Protection Agency (FEPA) guidelines for Nigeria (FEPA, 1991). The TSP concentration within all investigated workshops and the control site exceeded the recommended world standard of 40 μg/m³ with 98% of all observation not exceeding 120 μg/m³ for clean air. The level within the control site fell within acceptable limits (250μg/m³) recommended for Nigeria by FEPA (see arrows in figure 2).

All the investigated SSI gave rise to an average of at least a twofold increase in TSP concentration in air. The impact of BCR and WPB activities was highly seasonal; the dry season TSP concentration in air being more than double its wet season level within each workshop. Unlike the TSP level in the control site, the TSP concentration in the workshops during both seasons exceeded both the World Health Organization ambient

Table 4. Analysis of TSP in Nigeria (μg/m³)

LOCATION	SAMPLING SITE	RANGE	MEAN	SOURCE
Shagamu	Cement factory		13313	Oluwole et al., 1988 (in Oluyemi, 1996)
Ewekoro	Cement factory		14079	Oluwole et al., 1988 (in Oluyemi, 1996)
Bagauda	Non-industrial	13.3-52.1#	-	Beavington and cawse, 1978
		82.4-237.6*	-	
Jos	Urban	385-911*	-	Simoneit et al., 1988 (in Oluyemi, 1996)
Northern Nigeria	Cement factory	139-9368*	-	Adejumo et al.,
		51-2266		1994 (in Oluyemi, 1996)
Lagos	Residential	71.68-378.62	339.92	Ogunsola et al.,
	Industrial	112.01-691.90	301.68	1994
Ibadan	Urban, industrial	49-96		Olowande, 1977
	Rural suburbs	32-70		(in Akeredolu, 1989)
Ile-Ife	Non-industrial	120-750	380.13	Ogunsola et al., 1994
Ile-Ife	Urban, non-industrial	196-297*	249*	Akeredolu, 1989
		41-92#	56#	
Ile-Ife	Workshops	440-1480*	800*	
		230-850#	497#	This work
Ile-Ife	Residential	90-250*	170*	
		60-250#	150#	This work

* Dry Season # Wet Season

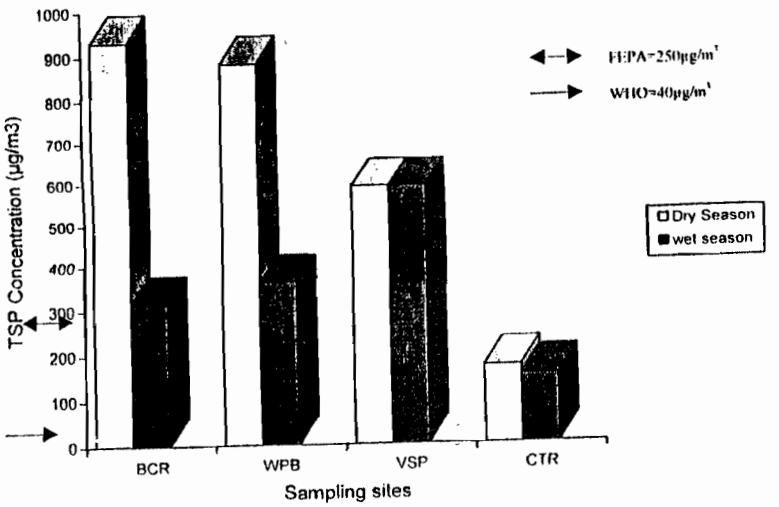

Figure 2. Concentration of TSP in selected workshops and control site in Ile-Ife

air quality standard of 40µg/m^3 and the Federal Environmental Protection Agency limits for Nigeria (250µg/m^3). This is a clear indication that airborne emissions from these SSI contributed to the rising concentration of TSP in air. Natural sources such as transatlantic transport of dust over West Africa during the dry season is suspected to contribute to the differences between TSP loading in the wet and dry seasons. According to Obioh et al (1993), "wind blown dusts emanating from the Sahara desert and transported across West Africa occurs with the onset of the north-east trade (Harmattan) winds in November and persists till middle February". Akeredolu (1989) also identified this source and maintained that the dust may persist till March. Also, meteorological factors such as variation in the frequency of rainfall and intensity of wind action may contribute to these differences (Pastuszka, et al., 1993). The seasonal variation is in conformity with the result (13.3-52.1 µg/m^3) for rainy season and (82.4-237.6 µg/m^3) for dry season obtained by Beavington and Cawse (1978) at Bagauda in Northern Nigeria (table 4).

When compared with Khartoum, the capital city of Sudan where a similar investigation was carried out by Eltayeb, et al, (1993), TSP recorded in this area of study was higher in spite of Khatoum having a higher concentration of small scales industries than Ile-Ife. This signifies air contamination cause by SSI.

CONCLUSION

From the monitoring of the concentration of TSP in the ambient air of SSI, it is observed that their activities give rise to high concentration of TSP and thus, air contamination. The environmental implication of the activities of these SSI could be enormous, considering the fact that these workshops are located within residential areas of Ile-Ife and they constitute major emission sources (as observed in figure 1). Thus, they may constitute a health risk to workers as well as other individuals who are not directly involved with the different occupations. In order to protect the workers and the general public from the risk of contamination with heavy metals/trace elements contained in TSP, the workers should be educated on the need to comply with appropriate environmental friendly technologies for sustainable industrial development and TSP recommended concentrations.

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