ASSESSMENT OF AIR POLLUTION IN RESIDENTIAL AREAS: A CASE STUDY OF KINONDONI MUNICIPALITY, TANZANIA

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ABSTRACT

Air pollution, just like any other type of pollution, produces harmful effects to man and his environment. In spite of knowing this, many less industrialised countries of the world have no air quality monitoring strategies in place. Consequently, documented evidence of air pollution studies in such countries is scarce. This is the case in Tanzania. This scenario is made worse by lack of scientific tools which could aid in identifying air pollution-prone areas with a view to aiding town planners in locating safe sites for schools, hospitals and residential areas as well as parks. In this paper, we present results of a study carried out in the city of Dar-es-Salaam, Tanzania on air pollution in residential areas. Results show significant air pollution in the studied areas. Moreover, both adults and children are at risk due to lead pollution in the air.

Keywords: Air pollution, suspended particulate matter, lead, nitrogen dioxide, risk assessment, carcinogenic risk

1. INTRODUCTION

Air pollution can be described as the presence of undesirable materials in the air in quantities large enough to produce harmful effects to man and his environment. Rapid urbanisation and concentration of economic activities in urban centres can cause air pollution unless air pollution control measures are put in place. Such pollution can arise from vehicle emissions and industrial activities. Combustion of traditional fuels such as wood and charcoal for domestic energy needs is another source of air pollution in both urban and rural areas. In as far as air pollution is concerned, common air pollutants include sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb), and suspended particulate matter (SPM). Available data shows that air quality in most major cities of the world has deteriorated to levels which make air quality management strategies necessary (Seinfeld, 1986). In man, air pollution can result in respiratory diseases like asthma and lung cancer, especially in the young and the elderly (Rwanga, 2005).

In the past several years, a growing body of scientific evidence has indicated that the air in homes and other buildings can be more polluted than outdoor air in even the largest and most industrialised cities. While it is true that pollutant levels from individual sources may not pose a significant health risk by themselves, most homes have more than one source contributing to indoor air pollution. Thus, the reaction and cumulative effects of these sources can and do seriously impact negatively on the health of an individual.

A study carried out in Kuwait (see Bouhamra and Abdi-Wahab, 1999) indicates that the distribution of carbon monoxide correlated positively with the number of heavy vehicles on the roads during rush hour. This implies that people living next to major roads are more likely to be exposed to carbon monoxide than those living further away. Another study carried out in the U.S on the exposure of 600 residents to toxic and carcinogenic chemicals concluded that indoor air in the homes outweighs outdoor air as a route of exposure to toxic chemicals (EPA, 1987).

In the environment, air pollution is a major contributor to effects such as acid rain, which damages soil, fish and vegetation (Acid Rain, 2001). However, by far the most serious long-term environmental effect of air pollution is global warming which now threatens the very existence of human life. Considering its effects and potential effects on man and his environment, air pollution is probably one of the greatest threats to sustainable development at present.

A few air pollution studies have been carried out in the city of Dar-es-Salaam (see NEMC,1993; Rwanga, 2005). The few existing studies carried out focused on air pollution related to traffic, hence they were conducted along roadsides, at road junctions and at bus stations. The current study was conducted in residential areas where young and old spend most of their time.

2. THE STUDY AREA

The city of Dar-es-Salaam, which is situated between 6º34' and 7º10' (Figure 1) is the prime city and the administrative, commercial, industrial and transport centre of Tanzania. It has an estima ted population of 3 million people, and is several times larger than the second city, Mwanza. Dar-es-Salaam has within its boundaries over half of the country's heavy industries (Othman, 1996). The climate is tropical-coastal, with a mean annual temperature of 26ºC, while the average humidity varies between 96% in the morning and 67 % in the afternoon. The average annual rainfall of 1100 mm falls mainly in the periods of November to December (short rains) and March to May (long rains). According to Othman (1996), the city has an annual physical expansion rate of 7.2% and an annual population growth rate of 4.7%.

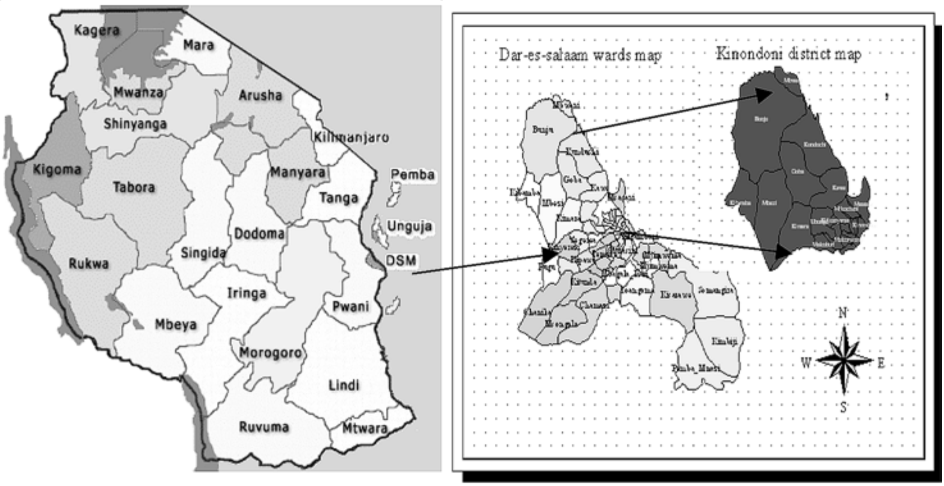

Fig. 1: Map of Tanzania and city of Dar-es-Salaam

3. PROBLEM DEFINITION

Air pollution studies in residential areas in the city of Dar-es-Salaam have never been conducted despite the fact that both young and old spend most of their time at home. In this study, we researched the variations in air pollution in residential areas and established maps to demarcate the most vulnerable areas using GIS. The specific objectives were:

(1) to determine the concentration of nitrogen dioxide, lead and suspended particulate matter in various residential areas;
(2) to determine pollution levels in the studied residential areas; and
(3) to conduct risk assessment.

4. METHODOLOGY

Three air pollutants, namely nitrogen dioxide (NO_2), suspended particulate matter (SPM) and lead (Pb) were measured at different locations within the study area (i.e. at Mikocheni, Kijitonyama, Sinza and Manzese). The analysis of NO_2, SPM and Pb was carried out using the Saltzman method, the filtration method and the atomic absorption spectrometric method respectively (WHO, 1976). In order to study the impacts of these pollutants on human health, the measurements were done in residential areas at human breathing height of 1.5m above the ground. The results were then compared with World Health Organisation (WHO) guidelines (WHO, 1989; WHO, 1986).

5. RESULTS

Nitrogen dioxide

The hourly concentration of nitrogen dioxide in the air in residential areas was found to range between 16 and 71 g/m^3. This is within the acceptable one-hour standards of 190-320 g/m^3 specified by WHO guidelines (www.worldbank.org/standards). The levels of nitrogen dioxide at all the studied locations are shown in Figure 3.

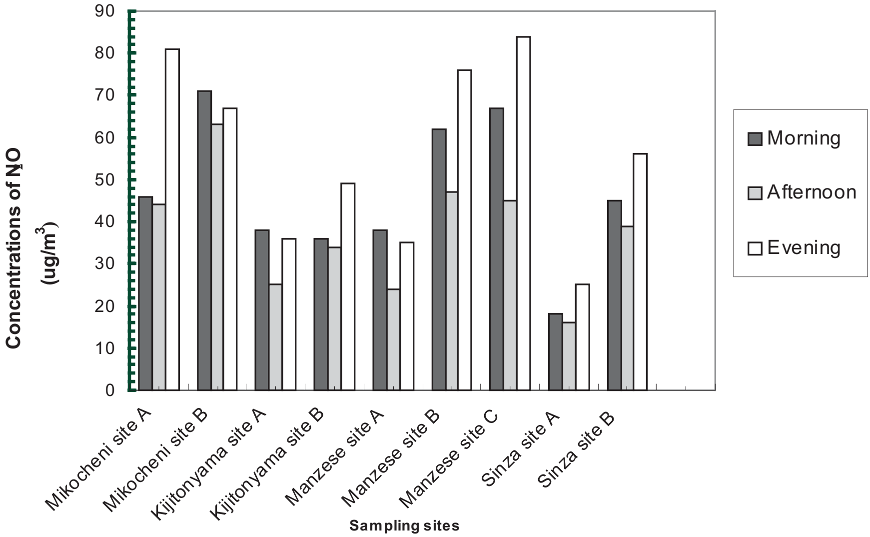

Figure 3: The average concentration of nitrogen dioxide in all sampling sites

The highest concentrations were observed in Mikocheni and Manzese areas while the lowest concentration was observed in the Sinza area. In most cases, the levels of these pollutants were higher in the morning and evening hours than during the afternoon hours (see Figs. 4 and 5).

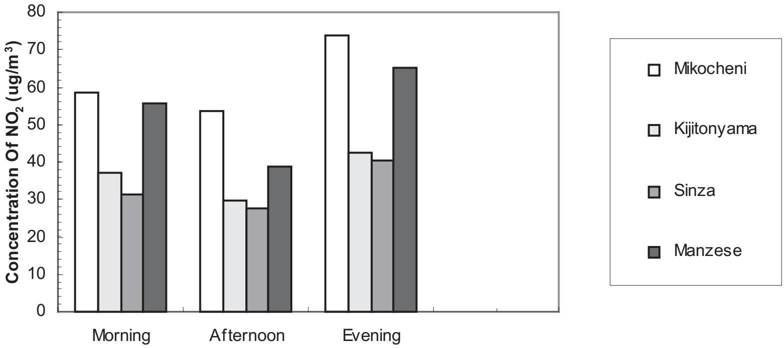

Figure 4: Temporal variations of average NO_2 concentration in the study areas

Temporal variation of NO_2 concentration during the day seems to be influenced by the activities producing this pollutant such as traffic flow. Higher concentrations are observed especially in the morning and evening when residents are moving from their homes to offices and vice versa. Other activities, besides traffic flow, which may generate NO_2 concentrations, include waste burning and industrial activities (especially in Mikocheni area).

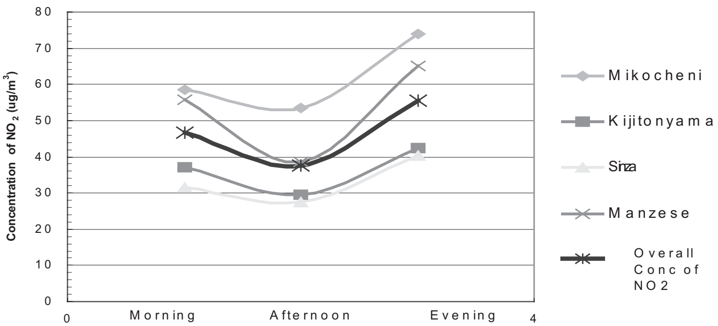

Figure 5: Average temporal variation of nitrogen dioxide concentration in a day

Suspended Particulate Matter (SPM)

Suspended particulate matter concentration at all sites was higher than the WHO recommended value of 150-230μg/m^3 for 24hrs. The levels of suspended particulate matter at all the studied locations are shown in Figure 6.

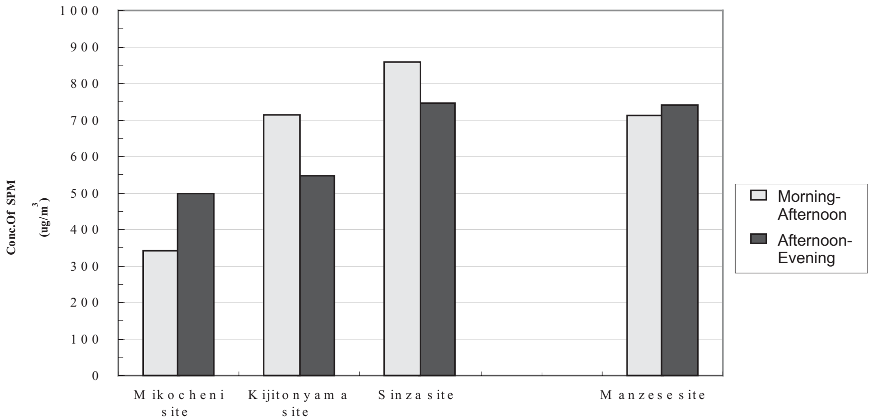

Figure 6: Temporal variation of average concentration of SPM

The six hourly concentration of SPM in residential areas in the study area ranges from 418.67 g/m^3 to 804 g/m^3. This is higher than the limit of 24-hr standards of 230 g/m^3 specified by WHO guidelines. The highest concentration was observed at Sinza area with an average concentration of 804 g/m^3 followed by Manzese with an average concentration of 727.67 g/m^3. The lowest level of SµM was observed at Mikocheni area which recorded an average concentration of 418.67 g/m^3 (see Figure 7).

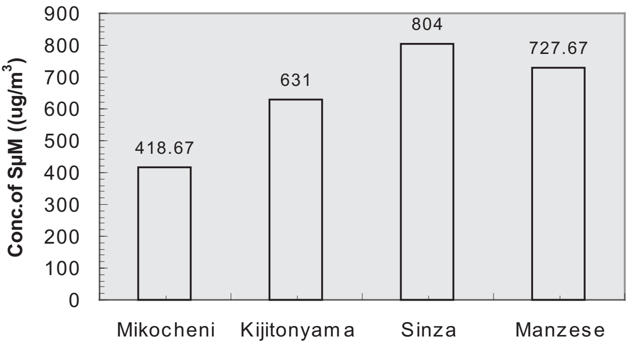

Figure 7: Average concentrations of SµM in the studied areas

In most cases, the levels of SµM pollutants were higher in the first six-hourly sampling times (i.e. morning to afternoon) than in the second session of the sampling time (i.e. afternoon to evening). These results were due to the activities carried on in the study areas, which included traffic movement, industrial, construction, garage and domestic activities. It also appears that, for these two sites, SµM could originate from multiple sources, which include vehicles passing by as well as dusty roads observed in these sites.

Particulate Lead (Pb)

Six-hourly concentration at all sites sampled exceeded the WHO recommended value of 1.5 g/m^3 for 24hours (WHO, 1989). The highest concentrations were observed at Sinza and Manzese areas while the lowest concentration was observed in Mikocheni area (see Figure 8).

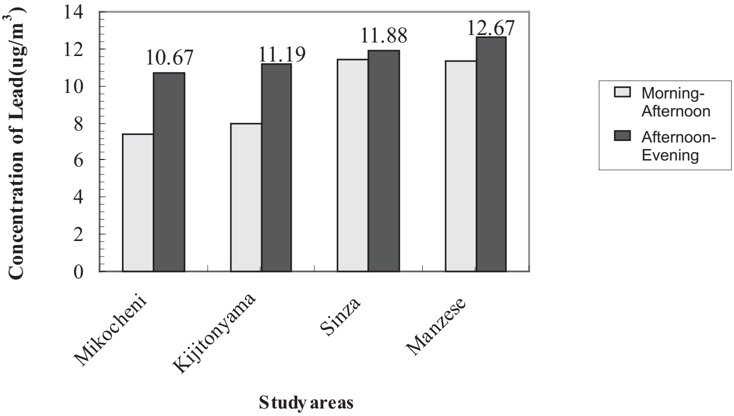

Figure 8: Temporal variation of average concentration of lead

In most cases, the level of lead pollutants was higher in afternoon to evening than in the morning to afternoon. This is due to the activities carried out in these areas within these time periods. These activities include traffic flow, industrial and garages activities. It also appears that, for these two sites, particulate lead could originate from multiple sources, which include vehicles passing by as well as dusty roads observed at these sites.

Risk Assessment

Risk characterisation was done using slope factor of lead adopted from USEμA (1986) cancer guidelines of 4.2×10^{-2}(mg/kg.day)$^{-1}$. The carcinogenic risk estimated is considered to be additional risk due to lead. Its source could be traced to traffic flow, industrial and garage activities which eventually find their way into the human body through inhalation. Other routes such as ingestion and dermal contact were not considered in this study. The risk assessment was based on the average concentration.

Table 1 shows the additional risk contributed by lead. From the results, about 48 adults out of an adult population of 606 767 in Kinondoni Municipality would get cancer if exposed for 20 hours per day for 50 years, and 12 children of a population of 476 746 in the same municipality, exposed for 20 hours per day for 10 years, are at risk of getting cancer.

Further, Table 1 and Figure 9 show that the risk of pollutant lead at all the sites is greater than the acceptable limit of 1 x 10^{-6} (USEPA, 1986), hence all the people living in these areas are at risk. The analysis shows that people of Manzese and Sinza are at more risk of being affected from lead pollutant than those in other areas. Moreover, the results further indicate that adults are at a higher risk than children. This is due to the fact that adults are mostly exposed to the ambient air in everyday activity.

Table 1: Risk Characterisation Summary

	CHILDREN				ADULTS			
Study area	Carcinogenic risk, R= CDI x P x 10^{6}	USEPA acceptable risk, R x 10^{6}	Children pop. at study areas	Pop. risk per people exposed Rx (Pop.)	Carcinogenic risk, R= CDI x P x 10^{6}	USEPA acceptable risk, R	Adult pop. at study areas	Pop. risk per people exposed
Mikocheni	18.83	1 x 10^{6}	20722	1	59.20	1 x 10^{6}	26374	1
Kijiton-yama	19.97	1 x 10^{6}	12005	1	62.77	1 x 10^{6}	15278	1
Sinza	25.05	1 x 10^{6}	16046	1	74.75	1 x 10^{6}	20423	2
Manzese	24.27	1 x 10^{6}	29421	1	76.26	1 x 10^{6}	37445	3
Kinondoni	25.06	1 x 10^{6}	476746	12	78.75	1 x 10^{6}	606767	48

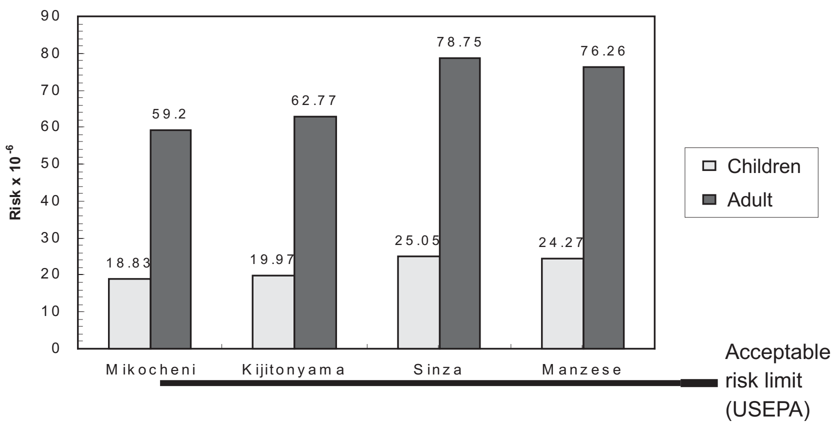

Fig. 9: Carcinogenic risk at studied sites

6. CONCLUSION

The study provided new data on ambient air levels of nitrogen dioxide, suspended particulate matter and lead. These pollutants were measured during daytime. The results showed that the pollutant levels for suspended particulate matter and lead were higher than the WHO-recommended levels for a healthy ambient air environment. The levels of each pollutant were found to vary from one location to another within the studied area. In general Sinza area was found to be more polluted with suspended particulate matter and lead than the other areas. With regard to nitrogen dioxide, Mikocheni area was found to have higher levels compared to the other areas.

The risk assessment was undertaken considering the people who spend most of their time in the residential areas. The unit risk realised was 78.75×10^{-6} for adults and 25.05×10^{-6} for children, both scenarios showing risk higher than the acceptable limit of 1×10^{-6}. Additional population risk contributed by lead was found to result in 48 cancer cases out of 606 767 exposed adults and 12 cancer cases out of 476 746 exposed children. Both scenarios predict population risks which are higher than the acceptable risk of 1 person per 1,000,000 population.

7. REFERENCES

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