ASSESSING THE RISK AND POTENTIAL OF PERSONAL EXPOSURE TO ROAD GENERATED POLLUTANT EMISSIONS THROUGH URBAN TRANSPORTATION SYSTEM

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ABSTRACT

This paper presents a study to assess the degree of personal exposure to traffic generated pollutant emission along urban arterials in Mosul. The traffic flow characteristics (volume, speed, density, and vehicle type) were determined in the field at selected locations on the arterials.The vehicular traffic which includes (drivers, number of passengers in vehicles on the road, and pedestrian) exposed to road generated emissions were obtained through field survey.The vehicle emissions of CO, VOC, and NOx were calculated using air pollution estimation computer model (Mobile 4.1). It was concluded that the emission of CO, VOC, and NOx exceeds the standard level requirements. The risk arising from personal exposure to traffic generated emissions of such pollutants was analyzed and the degree of personal exposure of road users (drivers, passengers, and pedestrians) to pollutants emission along urban arterials in Mosul was determined.

الخلاصة

يعرض هذا البحث دراسة لتقدير درجة التعرض الشخصية لملوثات ناتجة عن حركة المرور عبر طرق شريانية في الموصل0 ان خصائص حركة المرور (الحجم المروري, السرعة, الكثافة, ونوع المركبات) قد تم حسابها في الموقع عند نقاط مختارة على الطرق الشريانية0 اما حركة المرور والتي تشمل (السائقين, عدد الركاب في المركبات, والمشاة) المعرضين الى انبعاثات الطريق, فقد تم حسابها ايظا من خلال دراسة موقعية0

ان انبعاث الملوثات من عوادم المركبات والشاملة (CO,VOC, NOx) قد تم حساب نسبها باستخدام نمذجة برنامج تقدير ملوثات عوادم المركبات (Mobile 4.1)0 تم الاستنتاج بان انبعاث هذه الملوثات يتجاوز المستوى المقبول عالميا0 ان الخطورة الناتجة عن التعرض الشخصي لمستخدمي الطريق لمثل هذه الملوثات قد تم تحليلها وحساب درجة التعرض الشخصي لمختلف انواع مستخدمي الطريق وكذلك للساكنين لمثل هذه الملوثات حول وعبر الطرق الشريانية في مدينة الموصل

KEY WORDS
Assessment, Emission, Exposure, Pollutant, Risk

INTRODUCTION

Road generated emissions and public reaction to it have become a major problem in recent years, especially in densely populated areas. The highway planner may be concern with how pollutants emissions from traffic flow are perceived by persons living or working nearby.

THE PROBLEM AND THE CITY

Mosul is the second largest city in Iraq, it is located at the north with a total area of 32698 km^2 and an urban area of 220 km^2 . The projected population for the year 2004 is 2.7 million as per 1997 census. The city is surrounded by hills to the south and mountains to the north ,such topographical situation may act as a barrier trapping pollutants close to the city. Plastics , chemicals , drugs ,wood and portland cement factories are surrounding the major urban area within 15km from the city center. The city continues to grow and is expanding into surrounding agricultural areas. The central part of the city is a mixed commercial and residential area. **Table1** shows that the vehicles fleets tend to be old and poorly maintained, more than 93% of the passenger car and more than 94% of commercial vehicles are over 15 years old, and of these, most have engines in need of major repairs. It was felt that this will increase the significance of motor vehicle as a pollutant source and the quality of life of urban residents will continue to deteriorate.

Table –1 Classification of vehicles in Mosul by Category of model year as in December- 2004

Vehicle * Model year	Passenger Car	%	Commerical vehicles (pick up,bus,truck)	%
1954-1959	894	0.74	X	0
1960-1971	2972	2.4	8889	10.3
1972-1976	4476	3.7	6728	7.8
1977-1979	3873	3.2	6987	8.1
1980-1984	36472	30.3	35370	41.2
1985-1989	65451	54.5	24728	28.8
1990-1993	4866	4.0	2503	2.9
1994-1996	808	0.67	370	0.4
1997-2004	208	0.17	243	0.3
Total	120020		85818	

*** From Traffic Police department - Mosul**

FIELD WORK

The current investigation was confined to eleven selected portions of the major arterials lined by 2-3 story buildings on both sides of the road where the traffic pollutants emissions level were expected to be high. Such locations are located at crowded , commercial , residential and open area for comparison. **Plate 1** shows the observation points and the arterial studied.

Determination of traffic flow characteristics

The measurement of traffic volume and composition was conducted using the manual count system by field observer, the number of vehicles of each category was determined during 10 minutes, through each observation point at rush hour.

The time mean speed was recorded for each vehicle category by timing it over a 100m distance. A total of 12 vehicle samples of each category were tested for speed at each observation point. The elevated observation technique was followed so that the observers select typical vehicles at random and record pertinent data regarding their progress through a section of a roadway. Such technique is designed for short-run observations. The speed and volume measurements techniques were as per Pignataro (1973) and Sarsam(1999).Vehicles were assigned to one of two general categories, passenger car (gasoline fuelled) and commercial vehicles (includes pick up, buses and trucks which are mostly diesel fuelled). **Table 2** illustrates the traffic flow characteristics observed. The vehicular traffic which includes (drivers , number of passengers in the vehicle on the road and pedestrian) exposed to road generated emissions were obtained through field survey. An average vehicular occupancy factor of 3 was obtained from direct observation in the field.

Table – 2 Traffic flow characteristics observed along major arterials in Mosul.

Section	volume (vehicle/rush hour)	% passenger cars	% commerical (pick up, bus,trucks)	Average speed (km/hr.)
1 →	1104	82	18	50.7
←	1206	87.5	12.5	50.3
2 →	1596	80.0	20	57.3
←	1932	83.5	17	55.3
3 →	1692	79.4	20.6	56.5
←	2184	81.3	18.7	49.4
4 →	1128	68.6	31.4	51.5
←	930	74.1	25.9	48.5
5 →	1632	73.8	26.2	32.6
←	1662	74.4	25.3	41.3
6 →	942	67.5	32.5	48.1
←	1092	72.5	27.2	47.8
7 →	276	71.7	28.3	65.5
←	456	72.3	27.7	56
8 →	498	77.1	22.9	54
←	522	86.2	13.8	63
9 →	1932	90.9	9.1	45
←	1116	90.3	9.7	51
10 →	1674	90.6	9.4	63
←	1110	95.1	4.9	46.4
11 →	1368	91.2	8.8	42.8
←	1668	93.5	6.5	39.3

Calculation of pollutants emissions , dose and risk.

The vehicles emissions of CO, VOC and NOx were calculated using air pollution estimation computer model (mobile 4.1). Essam etal (1997). **Table 3** illustrates the pollutants emissions through rush hour on the arterials. The degree of exposure of road users as a unit life time occupational dose was calculated using the procedure suggested by Beyers etal (1984), and Ortolano (1997), while the risk was calculated using Peirce etal (1998) procedure.

Table – 3 Pollutant emissions through rush hour using ((Mobile 4.1))

Section	CO gm/km	VOC gm/km	NOx gm/km	CO mg/m^3	VOC mg/m^3	NOx mg/m^3	Traffic density Veh/km
1 →	7.5	0.95	1.387	2.70	0.343	0.501	21.7
←	7.81	0.968	1.40	3.12	0.387	0.560	24
2 →	6.25	0.875	1.375	2.89	0.405	0.637	27.8
←	6.56	0.887	1.375	3.82	0.517	0.802	35
3 →	6.25	0.875	1.375	3.120	0.437	0.687	30
←	7.18	0.975	1.376	5.280	0.718	1.021	44.2
4 →	7.5	0.937	1.381	2.750	0.343	0.506	22
←	8.1	0.98	1.39	2.592	0.313	0.444	19.2
5 →	13.1	1.42	1.54	10.91	1.183	1.283	50
←	10	1.17	1.43	6.7	0.783	0.958	40.2
6 →	8.12	1.0	1.39	2.652	0.326	0.454	19.6
←	8.43	1.0	1.4	3.203	0.380	0.532	22.8
7 →	5.0	0.78	1.37	0.350	0.054	0.095	4.2
←	6.25	0.87	1.36	0.843	0.117	0.183	8.1
8 →	6.87	0.92	1.37	1.051	0.140	0.209	9.18
←	5.0	0.81	1.36	0.685	0.111	0.187	8.28
9 →	9.25	1.07	1.41	6.582	0.761	1.003	42.7
←	7.5	0.95	0.95	2.725	0.345	0.345	21.8
10 →	5.0	0.81	1.36	2.200	0.356	0.598	26.4
←	8.75	1.05	1.40	3.500	0.420	0.560	24

RISK ASSESSMENT

Risk assessment involves the measurements of the severity of harm inherent in exposure to pollutant emissions, two types of population exposed to risk were identified :

a-The permanent population living and working near the arterial (on both sides and along).

b-pedestrians walking along the road , drivers and passengers of vehicles on the road.

Table 3 shows that the pollutant emissions are likely to represent maximum exposure through rush hour which people probably experienced at the kerb side of the arterial , the dwellers may be exposed to the same as demonstrated by Clench – Ass etal(1989). In measuring the potential health impact of population, it is important to determine the likely population exposure to pollutants. **Table4** shows the unit life time occupational dose of pollutant taken by the road user and dweller and the unit life time occupational risk of cancer per 1000 population for each of road users and dweller . The number of population at risk was also shown in the table, which was calculated using the traffic density and the vehicle occupational

factor. The dwellers are expected to experience a cancer risk five folds larger than road users. The cancer fatalities in Mosul were 1478 at 2004, 893 at 2000 , 830 at 1999, 750 at1998 and 600 at 1996 as obtained from Ministry of health annual report.**Equation 1,** which was obtained from Ortolano (1997) was adopted for calculation of unit life time occupational Dose, and the test conditions and variables were as suggested by Beyers & Dudas (1984).

(ULTO Dose) = Breathing x 365 x 70 x Dose response (1)

(m^3 / day) (days/year) (year) information (gm /m^3)

The risk analysis was conducted as per the procedure suggested by Peirce (1998) the calculation of unit life time occupational risk of Cancer was adopted using **Equation 2** suggested by WHO (1992).
EPA definition of Unit life time occupational risk implies exposure for 2000 hours per year for 47 years (a working lifetime) . peirce (1998).

Unit life time occupational risk of canser/1000 = [Latent canser x (10^3 x 10^3)] / [47 years x (2000/ 8760)] (2)

fatality

Table – 4 Degree of exposure to pollutant emissions and risk.

Section	*U.L.O Dose ((gm))						*U.L.O Risk of cancer/1000		
	Road users			Dweller			Road users		Dwellr
	CO	VOc	NOx	CO	VOc	NOx	Risk	Pop. **	
1 ←	115.8	14.7	21.5	347	44	64.5	23.5	56	3.6
→	113.9	16.6	24	342	50	72	20.4	72	3.1
2 ←	124	17.3	27.3	372	52	82	21.2	83	3.2
→	164	22.2	34.4	492	67	103	16.2	105	2.4
3 ←	133.9	18.7	29.4	402	56	88	19.6	90	3.0
→	226.6	30.8	43.8	680	93	132	11.8	133	1.8
4 ←	118.0	14.7	21.7	354	44	65	23.1	66	3.5
→	111.2	13.4	19.0	334	40	57	24.8	58	3.8
5 ←	468.5	50.7	55.0	1406	152	165	6.2	150	0.95
→	287.6	33.6	41.1	863	101	123	9.8	121	1.5
6 ←	113.8	14.0	19.4	341	42	58	24.2	59	3.7
→	137.4	16.3	22.8	412	49	68	20.2	68	3.1
7 ←	15.0	2.31	4.0	45	7	12	167.0	13	25.5
→	36.1	5.02	7.8	108	15	23	73	24	11.1
8 ←	45.1	6.0	8.9	135	18	27	59.5	28	9.1
→	29.4	4.7	8.0	88	14	24	84.7	25	12.9
9 ←	282.5	32.6	43.0	848	98	129	9.9	128	1.5
→	116.9	14.8	14.8	351	44	44	24.4	65	3.7
10 ←	94.4	15.2	25.6	283	46	77	26.4	79	4.0
→	150.2	18.0	24.0	451	54	72	18.6	72	2.8
11 ←	221.5	25.8	32.6	665	77	98	12.7	96	1.9
→	330.6	37.3	43.9	992	112	132	8.6	127	1.3

	***Unit lifetime occupational **In vehicle population**	***low values indicates high risk /1000 population**

CONCLUSIONS AND RECOMMENDATIONS:

1- Concentrations of CO, VOC and NOx and the life time occupational dose of such pollutants exceeds the WHO levels at some observation points. It is expected that air quality will deteriorate in the city.

2- The dwellers are expected to experience a cancer risk five folds larger than road users.

3- The emission per vehicle – km on the arterial in Mosul could be reduced by limiting the speed to a range of 60-65 km/hour.

Its recommended that a stringent control measures for traffic related pollutants should start in the city with direct field measurements of pollutants, collection and processing of vehicle emission data should be repeated peroidically.

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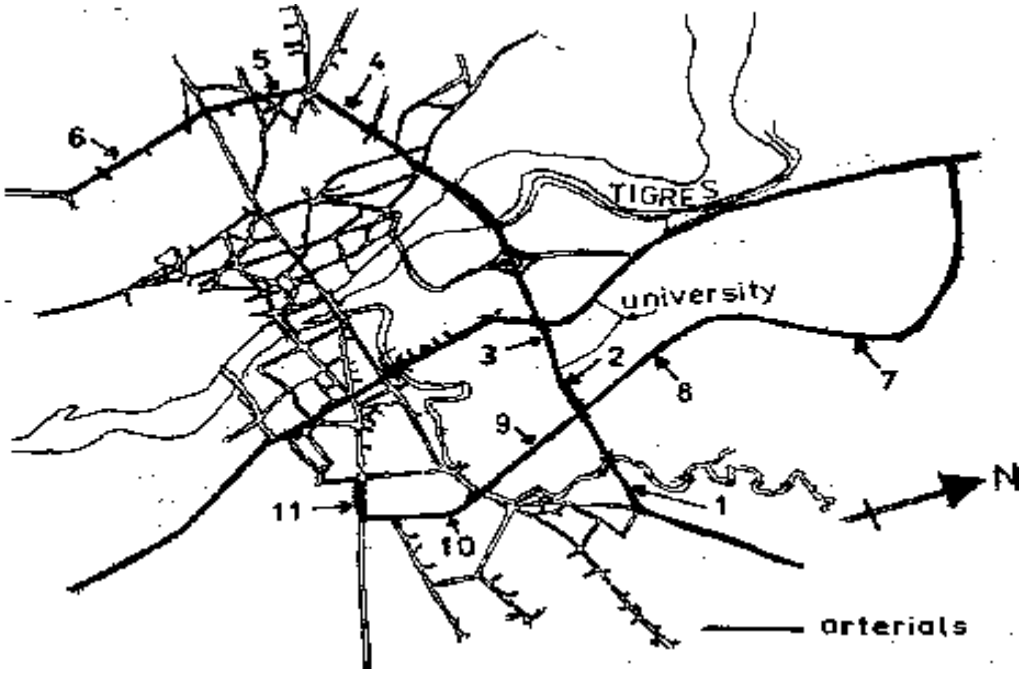

PLATE 1 – Location map, Mosul