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The Influence of Road Traffic on Heavy Metal Contamination of Road Dust and Roadside Soil along A Major RN3 Highway Through a Rural Area in Northeastern Algeria

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Abstract
This study examines the assessment of heavy metal contamination of pavement-side soils. In our case we studied the section of National Highway 3 (RN3). In the environment of sampling sites there is no industry or dangerous activity on the environment, the heavy metals addressed in this study are (Pb, Cu, Cr, Fe, Ni, Zn), their origin being road traffic. Results indicated that concentrations in road dust were higher than in soil. The distribution of heavy metal concentrations in dust is Fe>Pb>Zn>Cu>Cr>Ni, and the distribution in the ground is Fe>Pb>Cu>Zn>Cr>Ni in the direction of Biskra and in the opposite direction and decreases everything away from the road, while the distribution in the central solid ground is Fe> Cu>Cr>Cr>Zn>Ni. Climatic conditions such as wind, rainfall, temperature, humidity and the nature of the terrain were also significantly related to their enrichment in these roadside soils.
Keywords: Pollution; contamination; heavy metals; traffic; road; dust; environment; wind; pavement.

1. Introduction

Heavy metal soil pollution in rural areas near major highways is a major issue in roads with varied loads of traffic in rural areas. Traffic in major Algerian roads in rural areas is one of the sources of roadside soil pollution, especially with regard to heavy metal concentrations and their impact on the immediate environment of the road, for this purpose, it is necessary to identify, assess and quantify the concentrations of heavy metals in road dust and in the adjacent soil arable layer. Traffic and industrial emissions are considered important factors in metal pollution in road dust Duong et Lee [7]; Guney, M. et al. [39]; Thorpe, A., & Harrison, R. M. [40]; Wei, B., & Yang, L. [42]; Yuen, J. Q. et al. [36]. With the phasing out of leaded gasoline in developed countries and the implementation of other control measures, traffic-related metal emissions had significantly decreased Cheng, H., & Hu, Y. [42]; Preciado, H. et al. [43]. Whereas traffic-related emissions dominate metal pollution in road dust Thorpe, A., & Harrison, R. M. [40]; Wei, B., & Yang, L. [41]; Yuen, J. Q. et al. [36]. This can contribute to the enrichment of the Cr, Cu, Fe, Ni, Pb and Zn elements Apeagyei, E. et al. [44]; Duong et Lee, [7]; Gietl, J. K. et al. [45]; Gunawardana, C. et al. [46]; Thorpe, A., & Harrison, R. M. [40] ;(36) Yuen, J. Q. et al. [40]. Nevertheless, the chemical, resulting from the mixture of heavy metals linked to road traffic, varies considerably from study to study Gietl, J. K. et al. [45]; (46) Gunawardana, C. et al. [46]; Thorpe, A., & Harrison, R. M. [40], probably due to the difference in metal concentration in brake pads and tire materials, as well as the difference in road traffic volume density (Apeagyei, E. et al. [44]; Duong et Lee,[7]; Thorpe, A., & Harrison, R. M. [40]. Several studies have indicated that the contamination of soil and several types of roadside vegetation species by significant concentrations of heavy metals is due to the volume of road traffic Ho, Y. B., & Tai, K. M. [20]; Li, F. R., Kang,et al[3]; Banu Doganlar, et al. [22]; Sert, E. B., Turkmen, M., & Cetin, M. [21]; Chunjuan Bi et al [7]; Khan, A. B., & Kathi, S. [14]. In addition, the results could be used appropriately to monitor the aerial deposition of these roadside metals. Pagotto, C et al. [5] assessed the impact of certain physical infrastructure parameters (safety slides, pavement type, pavement slope) on the extent of heavy metal contamination, as well as the composition of the material near the emission source (road dust). According to Fakayode and Olu-Owolabi [30]; roads are known as the second most common source of urban pollution. Other studies have focused on the contamination of dust from roads and roadside soils in urban areas by heavy metals, Imperato, M. et al [15]; Yongming, H., et al. [17]; Shi, G., et al. [11]; Karim, Z., et al. [13]; Maeaba, W., et al. [26]; Xiao, Q., Zong, Y., Malik, Z., & Lu, S. [29]. They showed that levels of heavy metal concentration such as Pb, Cd, Cu, Cr, Ni, Zn, Fe and Co far exceeded the limits set for clean soils and their source came mainly from industrial derivatives, combined with traffic sources. Studies have examined the influence of industial activities and waste incinération on the accumulation and extent of heavy metal pollution in the complex system of surface soils and road dust; Chang, S.H et al [2]; Shi, G et al [12]; Chunjuan Bi et al [47]; They showed that the concentrations of these métals in road dust were generally higher than those in soils. Various pulications have examined the spatial distribution of heavy metals in dust and surface soils next to roads and their orogins.Kamani, H., et al.. [10]; Dragović, S. et al [16]; Ahmed, F., & Ishiga, H. [18]; Al-Khashman O. A. [19]; (Sollitto, D. et al [6]; Khan, A. B., & Kathi, S. [14]; Liu, E., et al. [4]; Zhang, H et al [1]; Alsbou, E. M. E., & Al-Khashman, O. A. [9]; They showed that the increase in anthropogenic trace metal elements in the surface environment can most likely be attributed to urbanization, rapid industrialization and increased vehicle emissions into the atmosphere. They revealed that the distribution of heavy metals in soil samples is affected by wind direction. They concluded that concentrations of these metals in soils are higher on the surface but decrease in low-lying areas and that the highest level of metals was found in eastern parts of roads due to prevailing wind. Also, levels of contamination of these metals decrease as one moves away from the side of the road. Authors have revealed that automobile traffic is the main source of pollution from road dust and adjacent soils with a contribution of more than 50%. In addition, unregulated incineration and hazardous waste dumps along the road were responsible for these contaminations. Pan, H., Lu, X., & Lei, K. [8] ; Khan, M. N., et al. [23]. Heavy metal contamination on human health was the concern of other researchers such as Wu, F., et al. [24]; Al-Shidi, H. K., et al. [27]; Hong, N. et al. [28]. They found that the health risks associated with heavy metal accumulation were higher in densely populated areas, high-traffic areas and industrial areas. They also showed that tire wear and exhausting diesel engines have a higher potential threat to human health as they generate high amounts of high-grade heavy metals. and revealed that gasoline and diesel emissions contributed significantly to the presence of Cr and Ni during braking, and tire wear generated large quantities of Cu and Zn. Men, C., Liu, et al [26], in order to assess the risks of environmental contamination by heavy metals, they concluded that the environmental risks specific to each source and the critical sources of heavy metals have changed with the changes in seasons, suggesting that different strategies should be adopted according to the seasons.

The objectives of this study were to: (1) Determine the concentrations of heavy metals in road dust; (2) Identify the sources of different heavy metals in soils and road dust; (3) Exploring the extent of heavy metal pollution in neighbouring soils; (4) Propose a protective easement on either side of the road.

2. Material and Methods

2.1 Study area

The study area is an agricultural area far from all industrial activities, located in the commune of Oued-echaaba wilaya of Batna in north-east Algeria, on a section of the national road three called (RN03), linking the Algerian north to the extreme south of Algeria, from the wilaya of Skikda to the wilaya of Tamanrasset with a traffic of 29521 vehicles per day. the section in question is a duplication of 7m of width on either side, the stretch of road is built in embankment with full central land of 5.5m width, the type of pavement is a classic pavement, the remediation of the road is provided by earth ditches in triangular shape on both sides of the roadway, with a depth of 1.5m, a width to the mirror. The city has a semi-arid climate with hot summers, cold winters and annual rainfall of around 346 mm, humidity is 53% and the maximum wind speed is 4.3m/s.

2.2 Samples and sampling

Soil sampling is done using a stainless transplant (cleaned after each sample with distilled water) at the level of 36 points arranged on either side of the roadway and 3 points in the TPC see Figure 1. These samples resulted in the preparation of 15 composite and homogeneous soil samples. All samples were placed in airtight polyethylene bags, labelled and brought back to the laboratory. Prior to the analysis, all samples were put to the oven at 105oC for 24 hours for drying, crushed with porcelain mortar, then sifted to 2mm and finally ground in a type disc grinder (DM200). Road dust samples were collected about three weeks after a thunderstorm, and the weather was sunny during sampling, clean plastic brushes and brushes were used to collect road dust samples Ashbaugh, L. et al. [32]; Banerjee, A. D. [33]; six points were taken on the pavement's bearing layer on an area of 7 m2 on both sides of the roadway. A sampling was taken at the roundabout. During the preparation, small pebbles, cigarette butts, hair and other plant debris were removed. The samples were carefully mixed to obtain compound samples. The samples were placed in airtight self-sealing polyethylene bags labelled and brought back to the laboratory for drying at 105oC, and then sifted into a sieve with a mesh of 0.5mm. Soil and road dust samples were kept at 4oC until they were analyzed.

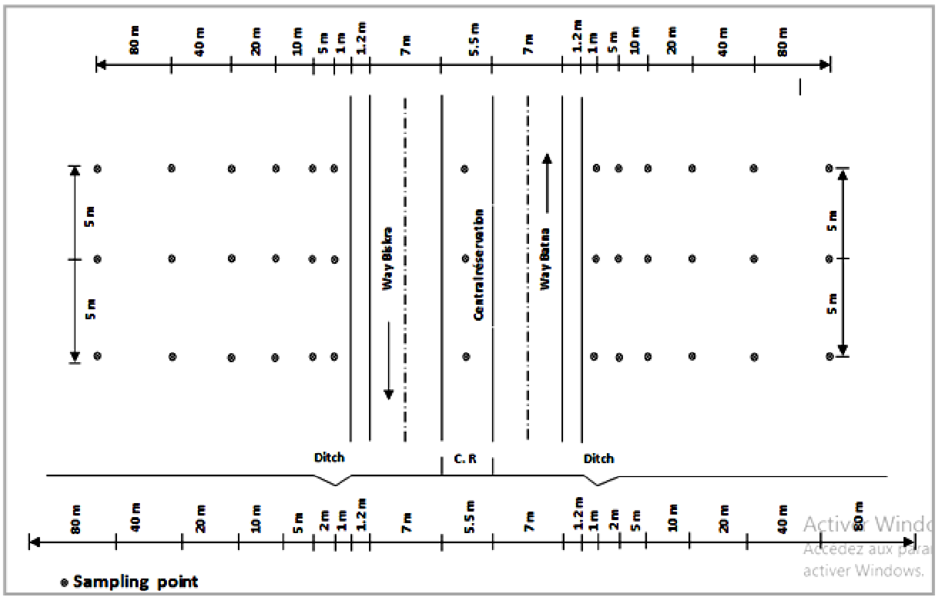

Figure 1. Location of sampling points.

2.3 Granulometric analysis

The granulometric analysis of the samples was carried out using a laser granulometer (Partica LA-960 HORIBA Laser Scattering Particle Size Distribution Analyzer). The results show a rather coarse nature for soil samples than for road dust.

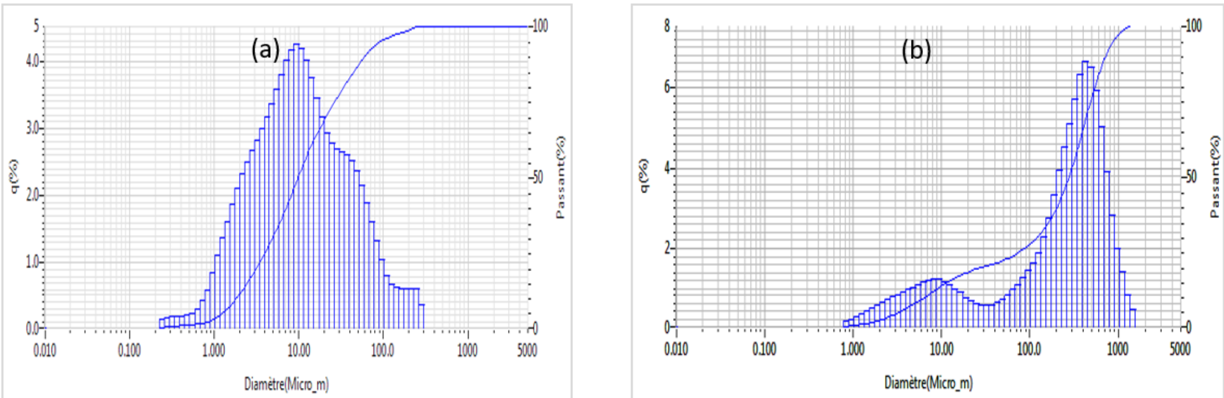

Figure 2. Granulometric curves (a) soil; (b) road dust.

2.4 Preparing Lozenges

The pellets are obtained by compressing the powder using a manual press. A boric acid binder can be added to give the lozenge a good mechanical solidity. The samples are then ready to be analyzed, the lozenge to a circular shape of 25mm in diameter, 5mm thick, and a weighte equal to 8g of powder. Samples zer analyzed by a wave lenght dispersion x fluorescence spectrometer (WDXRF) (ZSX Primus IV regaku fluorescence spectrometer).

3. Estimated Intensity of Contamination

The intensity of soils contamination by heavy metals was assessed from two indices : the enrichment factor (EF) and the geo-accumulation index (Igeo), theire principle is based in the comparison of measured values against reference values.

3.1 Enrichment FACTOR

The Enrichment factor is a parameter that allows us to see whether the concentration of heavy metals obtained in soils are anthropogenic or natural in origin. Maeaba, W et al 2020(26); if EF close to 1 indicates a natural source while EF > 10 suggests an anthropogenic source. According to Yen, J.Q et al (2012) (36) the Enrichment factor (EF) is defined by:

$$\mathbf{EF} = \frac{\left(\frac{C_i}{Fe}\right)_{\mathbf{Sample}}}{\left(\frac{C_i}{Fe}\right)_{\mathbf{Background}}}$$

Or:

$\left(\frac{C_i}{Fe}\right)_{\text{Sample}}$ and $\left(\frac{C_i}{Fe}\right)_{\text{Background}}$ are the ratios of metal concentration (i), standardizer (Fe) in sample, metal concentration(i) and standardizer (Fe) in the background material, respectively. In this research, the (Fe) has been used as a standardizer because it has low variability in occurrence and is a main component of thr Earth's crust Khademi, H et al [37]; Guo, G, Zhang, D. [25]; Maeaba, W et al [26]; and soils 80m from the roadway were used as reference materials, Yen, J.Q et al [36] and Pagotto, C et al [5]. The level of metal pollution can be categorized into five categories Sutherland, R. A.

EF < 2 Deficiency to minimal enrichment;
2 < EF < 5 Moderate enrichment;
5 < EF < 20 Significant enrichment;
20 < EF < 40 Very high enrichment;
EF > 40 Extremely high enrichment;

3.2 Geo-Accumulation Index (Igeo)

Guo, G., Zhang, D. [25]; Hakanson, L. [31]. To quantify the degree of metal contamination of dust and road side soils, the geo-accumulation index (Igeo) Duong, T. T., Lee, B. K. [7] was calculated on the basis of:

$$\mathbf{Igéo} = \mathbf{log2}\,\frac{\mathbf{C_i}}{\mathbf{1.5B_n}}$$

Or:
Igeo: Geo-accumulation index;
log2: basic logarithm 2;
i: item considered;
C: concentration measured in the sample;
B: geochemical background;
1.5: is a factor used because of possible variations in background data due to lithological variations Gope, M. et al. [34]; Guo, G., Zhang, D. [25].

In addition, Gasser, T., Muller, H. G. [35] defined a scale of values with six classes based on the intensity of pollution. As shown below:

Igeo < 0uns contaminated.
0 < Igeo < 1untaminated to moderately contaminated.
1 < Igeo < 2moderately contaminated.
2 < Igeo < 3moderately to highly contaminated.
3 < Igeo < 4highly contaminated.
4 < Igeo < 5 heavily contaminated.
Igeo > 5 extremely contaminated.

3.3 Statistical Analysis

The results were analyzed statistically using SPSS ver 20 software to determine the different correlations that exist between the metals (Fe, Zn, Ni, Cu, Cr, Pb) studied, Pearson correlation matrixes were established for a confidence interval of 95 and the level of significance was set at P< 0.05.

4. Results and Discussions

In this study, the results show that heavy metals concentrations in road dust are higher than those found in soils, and that heavy metals in soils decrease in soils by moving away from the road axis Tables 1, 2 and 3. The distribution of heavy metals in road dust is in the order of Pb >Zn > Cu. > Cr > Ni, while in the soils (Batna to Biskra and Biskra to Batna direction) is the order of Pb > Cu > Zn > Cr > Ni. In the central solid earth, the distribution is in the order of Cu > Cr > Pb > Zn >Ni. The high levels of lead in the dust are due to the overuse of leaded gasoline in third world countries, notably Algeria. In addition, the concentrations of (Cu, Zn, Cr, Ni) are due to the use of spare parts, braking system pads (discs and brake pads) and the abrasion of tires whose counter-manner is very marked in the markets. For iron, there is a high surface and roadside content. Presumably there is a road-related contribution that is more or less masked by the high concentrations of this element in natural soils. It has also been observed that the transport of dust through the various channels (hydraulic, wind, dry fallout) directly affects the quality and degree of soil pollution as shown in the Figures 2, 3 and 4.

Table 1. Concentration of heavy metals in the soil (Direction Batna to Biskra).

Elements	*Cr*	*Fe*	*Zn*	*Ni*	*Pb*	*Cu*
TPC	197.74	38958.42	110.87	99.81	171.74	197.96
1 m	145.74	37699.44	210.49	90.38	262.72	234.23
5 m	84.74	46722.13	122.92	82.52	208.88	77.37
10 m	92.99	53926.29	N.D	17.02	91.91	28.71
20 m	97.11	54555.78	51.53	12.95	41.78	12.17
40 m	99.27	48820.43	47.3	18.16	29.15	6.35
80 m	71.74	52597.37	43.04	8.59	9.75	2.09
V max	197.74	53926.29	210.49	99.81	262.72	234.23
V min	71.74	37699.44	43.03	8.59	9.75	2.09
V med	112.75	47611.4	97.69	47.06	116.56	79.84
Gap-type	43,96	6932,24	69,97	41,43	98,47	96,99

Table 2. Concentration of heavy metals in the soil (Direction Biskra to Batna).

Elements	*Cr*	*Fe*	*Zn*	*Ni*	*Pb*	*Cu*
1 m	154.48	41896.04	164.7	99.81	253.44	237.39
5 m	93.16	51758.05	118.1	98.23	248.79	78.32
10 m	92.11	54206.06	66.86	69.24	160.6	31.51
20 m	91.58	52177.72	59.63	19.16	90.05	18.48
40 m	86.99	52107.76	40.23	16.23	72.41	9.09
80 m	N.D	54415.89	48.07	N.D	11.42	4.84
V max	154.48	54415.89	164.7	99.81	253.44	237.39
V min	86.99	41896.04	48.07	16.23	11.42	4.84
V med	103.66	51093.5	82.931	60.53	139.45	63.27
Gap-type	32,91	4646,84	48,51	42,67	98,71	89,340

Table 3. Concentration of heavy metals in road dust (D, G, A).

Elements	*Cr*	*Fe*	*Zn*	*Ni*	*Pb*	*Cu*
dust D	215.53	34062.39	316.54	103.74	368.65	276.82
Dust G	214.16	26928.17	156.67	101.38	380.62	269.72
dust R	212.11	25319.48	261.91	99.81	309.13	272.88
V max	215.53	34062.39	316.54	103.74	380.62	276.82
V min	212.11	25319.48	156.67	99.81	309.13	269.72
V med	213.93	28770.0	245.04	101.64	352.8	273.14
Gap-	1,72	4653,38	81,26	1,98	38,28	3,55

Note:
D: in the direction Batna to Biskra.G: in the direction Biskra to Batna.A: in the roundabout.

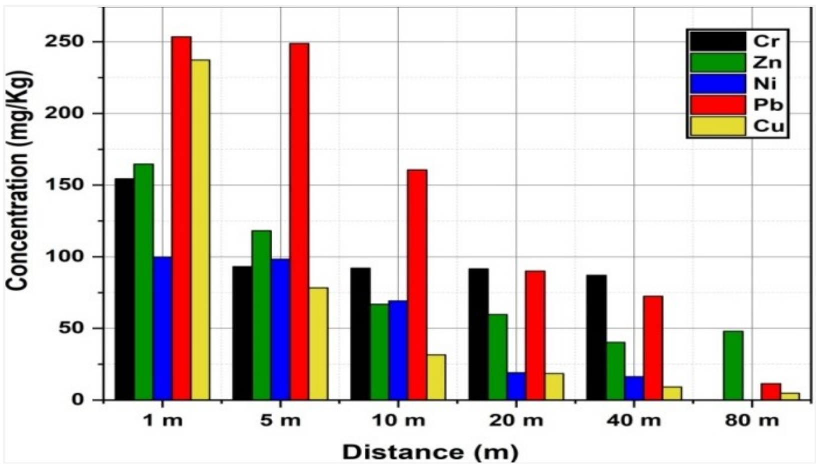

Figure 3. Concentration of heavy metals in the soil (direction Batna to Biskra).

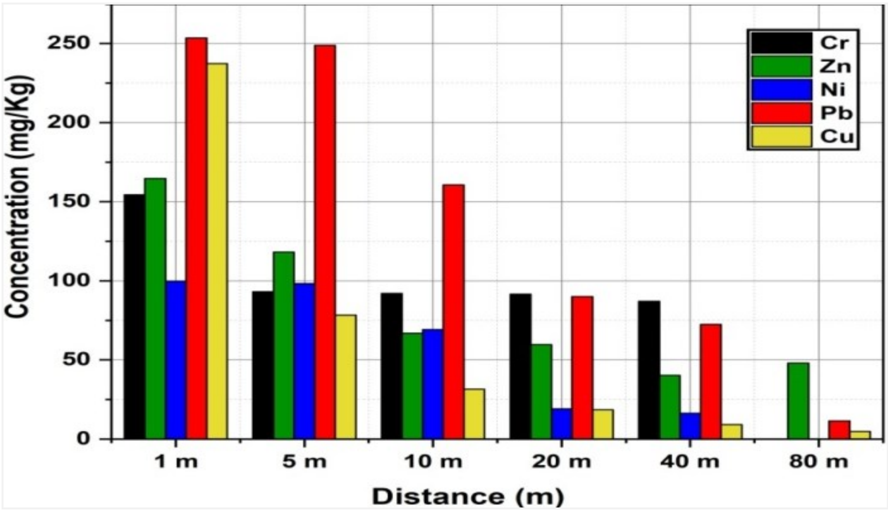

Figure 4. Concentration of heavy metals in the soil (direction Biskra to Batna).

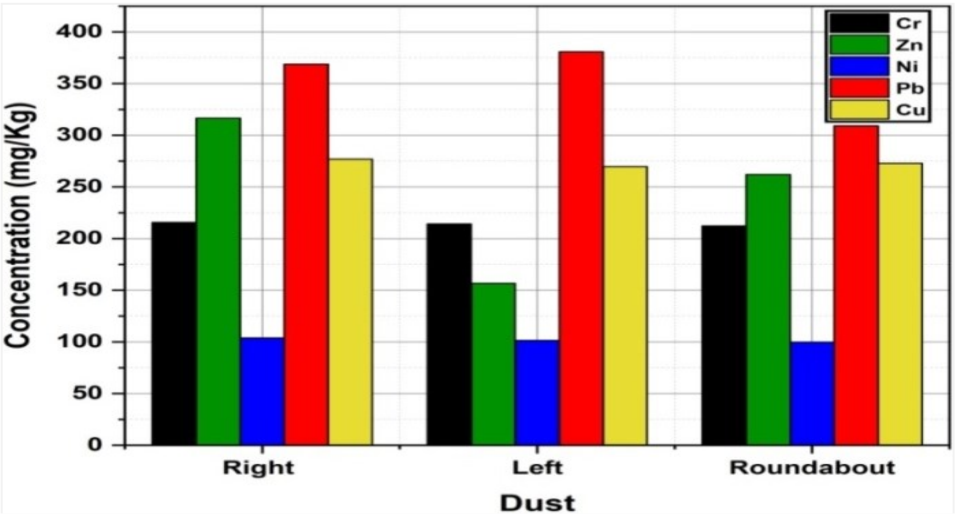

Figure 5. Concentration of heavy metals in road dust (D, G, A).

4.1 Enrichment Factor (EF)

These results suggest that for road dust: Cu is extremely enriched; Pb has very high enrichment and Zn, Ni and Cr have moderate to significant enrichment, while for soils (in both directions Batna-Biskra, Biskra-Batna and in the TPC): the Pb has a very high enrichment for distances (1m.5m) and significant to moderate for distances (10m, 20m, 40m) and minimum at 80m; for the Enrichment Cu and extremely high in (TPC, 1m, 5m) and significant to moderate to (10m, 20m, 40m) and minimal at 80m; for the neither enrichment and significant in (TPC, 1m, 5m, 10m) and moderate from (20m, 40m) and minimal to 80m. All elements have an FE that ranges from (moderate to strong) to (extremely contaminated), reflecting the high anthropogenic load of these metals in the study area. However, differences can be attributed to the different approaches used in methods of calculating enrichment factors.

Table 4. Enrichment Factor Values (EF) in the soil (direction to Biskra).

Distance	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fe)*
TPC	17.62	2.76	2.57	11.62	94.91	0.74
1 m	26.95	2.03	4.89	10.53	112.30	0.72
5 m	21.43	1.19	2.86	9.61	37.09	0.89
10 m	9.43	1.29	N.D	1.98	13.76	1.02
20 m	4.3	1.35	1.19	1.51	5.83	1.04
40 m	2.99	1.38	1.1	2.11	3.04	0.93
80 m	1	1	1	1	1	1

Table 5. Enrichment Factor Values (EF) in the soil (direction to Batna).

Distance	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fer)*
1 m	22.2	2.93	3.43	14.23	49.11	0.77
5 m	21.79	1.77	2.46	14.00	16.20	0.95
10 m	14.07	1.75	1.39	9.87	6.52	0.99
20 m	7.9	1.74	1.24	2.73	3.82	0.96
40 m	6.34	1.65	0.83	2.313	1.88	0.96
80 m	1	1	1	1	1	1

Table 6. Enrichment Factor Values (EF) in Road Dust.

Elements	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fe)*
Dust D	37.82	4.09	7.36	14.79	132.72	0.62
Dust G	39.05	4.06	3.64	14.45	129.31	0.49
Dust R	31.71	4.02	6.08	14.23	130.83	0.46

Note:
D: in the direction Batna to Biskra; G: in the direction Biskra towards Batna.

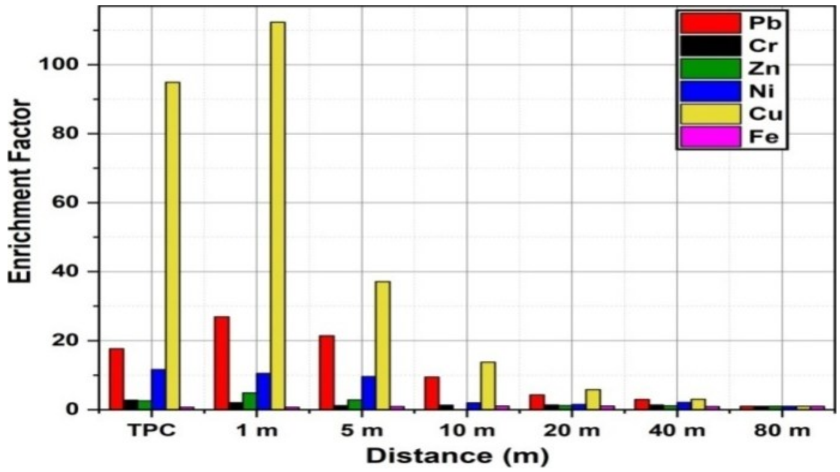

Figure 6. Enrichment factors (EF) in the soil (Direction to Biskra).

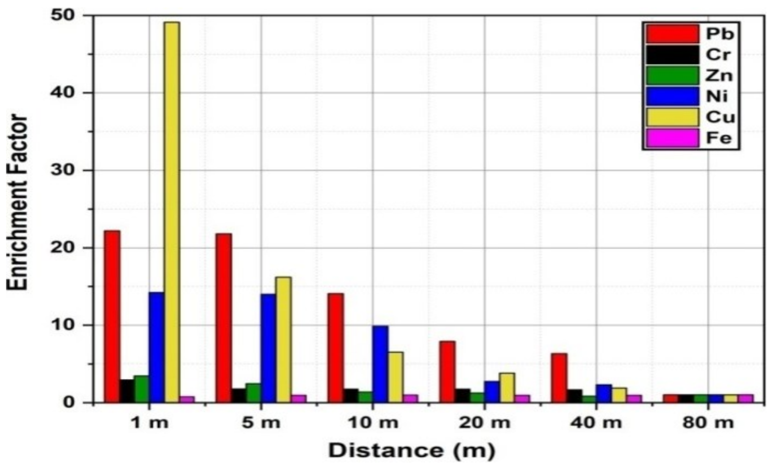

Figure 7. Enrichment factors (EF) in the soil (Direction to Batna).

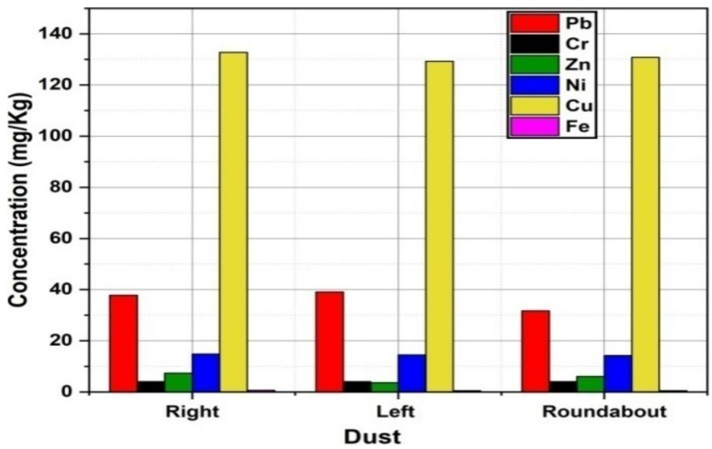

Figure 8. Enrichment factors (EF) in road dust.

4.2 Geo-Accumulation Index (Igeo)

The values of the calculated geo-accumulation indices (Igeo) are presented in the tables 9; 10; and 11 The results of the index (Igeo) in road dust show different levels of contamination depending on the element:

For Pb and Cu, Igeo ranges from (high to extremely contaminated) to (extremely contaminated); for Cr and Zn, Igeo varies between (moderately contaminated) to (moderately contaminated to highly contaminated), and for Ni Igéo is highly contaminated. The results of the index (Igeo) in soils (Batna-Biskra direction, Biskra-Batna, TPC) indicate different levels of contamination, depending on the element and distance: For Pb and Cu, Igeo in (TPC, 1m, 5m) varies between (highly contaminated) to (highly contaminated) and for distances of 10m, 20m, 40m to (moderately to highly contaminated) and at 80m the Igeo varies between (untaminated) to (not to moderately contaminated). For Cr and Zn, Igéo varies from (untaminated) to (not moderately contaminated) to (moderately contaminated) in all points. For the Ni, the Igeo for (TPC, 1m, 5m, 10m) varies between (moderately to highly contaminated) to (highly contaminated) and for distances (20m, 40m, 80m) varies from (untaminated) to (not to moderately contaminated).

Table 7. Values of geo-accumulation indices (Igeo) in the soil (Direction to Biskra).

Distance	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fe)*
TPC	17.62	2.76	2.57	11.62	94.91	0.74
1 m	26.95	2.03	4.89	10.53	112.30	0.72
5 m	21.43	1.19	2.86	9.61	37.09	0.89
10 m	9.43	1.29	N.D	1.98	13.76	1.02
20 m	4.3	1.35	1.19	1.51	5.83	1.04
40 m	2.99	1.38	1.1	2.11	3.04	0.93
80 m	1	1	1	1	1	1

Table 8. Values of geo-accumulation indices (Igeo) in the soil (Direction to Batna).

Distance	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fer)*
1 m	22.2	2.93	3.43	14.23	49.11	0.77
5 m	21.79	1.77	2.46	14.00	16.20	0.95
10 m	14.07	1.75	1.39	9.87	6.52	0.99
20 m	7.9	1.74	1.24	2.73	3.82	0.96
40 m	6.34	1.65	0.83	2.313	1.88	0.96
80 m	1	1	1	1	1	1

Table 9. Values of geo-accumulation indices (Igeo) in Road Dust.

Elements	*FE (Pb)*	*FE (Cr)*	*FE (Zn)*	*FE (Ni)*	*FE (Cu)*	*FE (Fe)*
Dust D	37.82	4.09	7.36	14.79	132.72	0.62
Dust G	39.05	4.06	3.64	14.45	129.31	0.49
Dust R	31.71	4.02	6.08	14.23	130.83	0.46

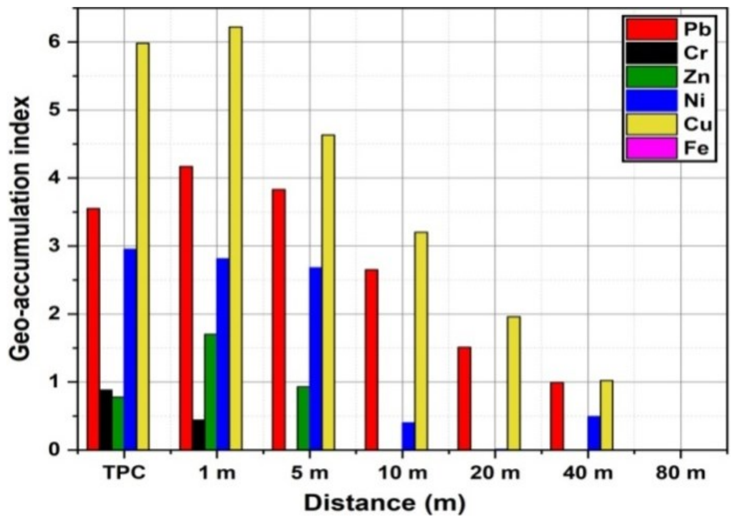

Figure 9. Geo-accumulation indices (Igeo) in the soil (Direction to Biskra).

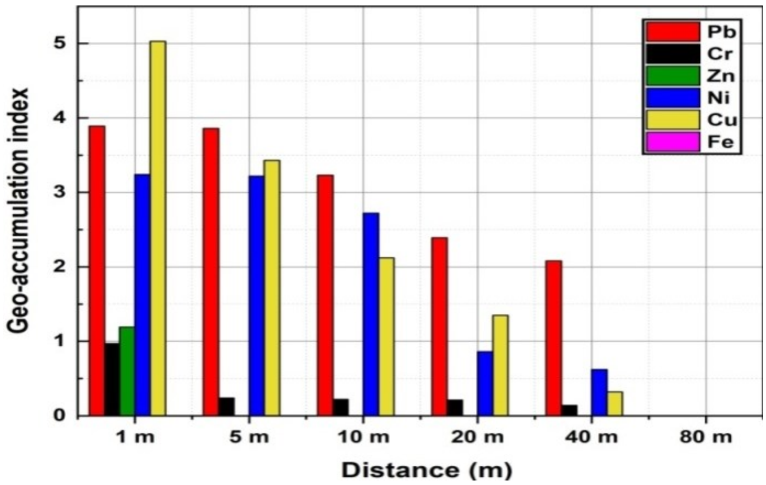

Figure 10. Geo-accumulation indices (Igeo) in the soil (Direction to Biskra).

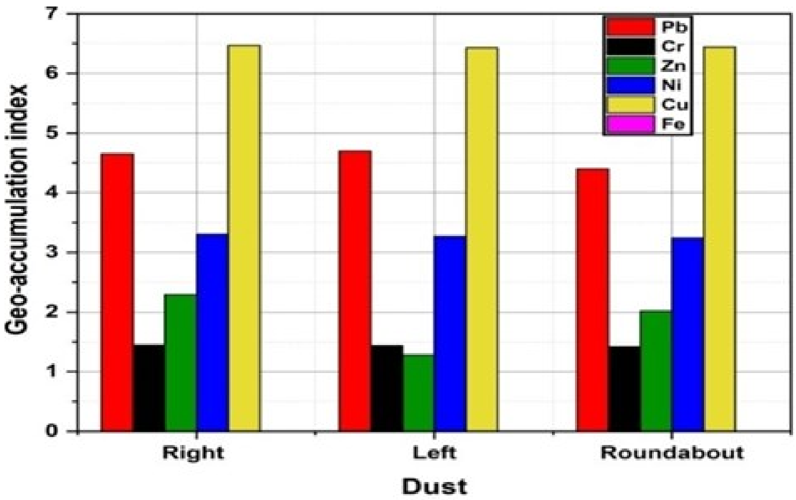

Figure 11. Geo-accumulation indices (Igeo) in in road dust.

4.3 Correlations Between Heavy Metals

Tables 10, 11 show Pearson's correlation matrixes between the heavy metals studied in soil samples. Analysis of these matrixes shows very significant and positive correlations ($P < 0.05$) between Ni/Pb, Pb/Ni and Ni/Cu, Cu/Ni; and negative correlations between Fe/Ni, Ni/Fe and Fe/Cu, Cu/Fe, and significant and positive correlations between Zn/Ni, Ni/Zn, Zn/Pb, Pb/Zn, Zn/Cu, Cu/Zn Cu/Pb, Pb/Cu, Cu/Cr/Cu, and negative between Cr/Fe, Fe/Cr, Fe/Zn, Zn/Fe Pb/Fe, in the ground (Batna to Biskra) and in the opposite direction (Biskra to Batna) very significant correlations were observed between Zn/Cu, Cu/Zn, Ni/Pb, Pb/Ni and negative between Cr/Fe, Fe/Cr Fe/Cu, Cu/Fe and positive significant correlations between Cu/Zn, Zn/Cu, Cr/Cu, Cu/Cr, Zn/Ni, Ni/Zn, Zn/Pb, Pb/Zn and negative between Zn/Fe and Fe/Zn. The high correlations noted suggest that these parameters are governed by the same mechanism. On the other hand, the positive and significant correlations between different heavy metals reflect a common source, while the significant and negative correlations between the heavy metals studied indicate different sources.

Table 10. Correlation matrix (Pearson) of the soil (Direction Batna to Biskra).

Corrélation de Pearson	*Cr*	*Fe*	*Zn*	*Ni*	*Pb*	*Cu*
Cr	1	-0,816*	0,526	0,733	0,544	0,839*
Fe	-0,816*	1	-0,868*	-0,912**	-0,811*	-0,947**
Zn	0,526	-0,868*	1	0,836*	0,862*	0,859*
Ni	0,733	-0,912**	0,836*	1	0,917**	0,904**
Pb	0,544	-0,811*	0,862*	0,917**	1	0,871*
Cu	0,839*	-0,947**	0,859*	0,904**	0,871*	1

Table 11. Correlation matrix (Pearson) of the soil (Direction Biskra to Batna).

Corrélation de Pearson	*Cr*	*Fe*	*Zn*	*Ni*	*Pb*	*Cu*
Cr	1	-0,928**	0,845*	0,714	0,778	0,917*
Fe	-0,928**	1	-0,855*	-0,582	-0,635	-0,958**
Zn	0,845*	-0,855*	1	0,881*	0,890*	0,954**
Ni	0,714	-0,582	0,881*	1	0,981**	0,761
Pb	0,778	-0,635	0,890*	0,981**	1	0,774
Cu	0,917*	-0,958**	0,954**	0,761	0,774	1

5. Conclusion

The objective of this study is to assess the level of heavy metal contamination of roadside soils exposed to road traffic on a major road (national road three RN03) located in the commune of Oued-Echaaba, wilaya de Batna. The results obtained show that all the heavy metals detected (Fe, Zn, Ni, Cu, Cr, Pb) have a close link with road traffic. All of these elements had some higher levels than the reference values. The general sequence of metal element levels in these soils is: Fe > Zn > Cr > Cu > Ni > Pb. High concentrations of heavy metals were found in soils near the road at distances of 1 to 5m and in central solid earth (TPC). These concentrations decrease exponentially as they move away from the highway. Although all elements have achieved moderate to extremely enriched enrichment for road dust, and minimal enrichment in soils at 80m distance, to extremely high in soils (TPC, 1m, 5m), the RESULTs of FE are confirmed by the results of Igeo whose contamination is varied between uncontaminated at a distance of 80m, to highly contaminated in (TPC, 1m, 5m). Contamination of these soils is, on the one hand, a risk of poisoning through the food chain for the populations that use them for their crops and on the other hand, a risk for contamination of groundwater. Thus, an easement must be taken care of whose concern to avoid such contamination.

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Conflicts of Interest

The authors declare no conflict of interest.

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