Ecological and Health Risk Assessments of Trace Elements in Al-Shaibah Dust, Basrah city, Iraq

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Abstract

This study goals to evaluate the pollution loads of contaminated dust fallen in areas near the oil refinery in Al-Shaibah area and areas around it in Basrah, Iraq between June 2011 and November 2012 in nine stations. Trace elements in dust under study are: (1.chromium Cr, 2.cadmium Cd, 3.nickel Ni and 4.lead Pb). Chronic daily intake *CDI* for these trace elements through (a.ingestion, b.inhalation and c.dermal contact) is calculated, (the total non-carcinogenic hazard quotient *HI*) and (the total carcinogenic risk *TCR*) are calculated. The order of non-carcinogenic hazard quotient for trace elements in dust is: (Cr > Pb > Cd > Ni). Carcinogenic risk order for trace elements in dust is: (Cr > Cd > Pb > Ni), study area is in safe of non-carcinogenic and carcinogenic impact on human health. Finally the ecological risk is evaluated in two indices: integrated pollution level in the environment C_{deg} and potential ecological risk *RI*. The order of *RI* for trace elements is: (Pb > Cd > Ni > Cr), this study indicates that all stations have low "potential ecological risk".

Key words: Human Health, Trace elements, Dust, Exposure Risk, Ecological Risk.

1. Introduction

The rapid industrialization in the world cause more pollution to environment, which represent a great real threat to human health. The essential pollutants that affecting on environmental are trace elements. Soil represents the natural-dynamic cover of the earth is sever from contamination with trace elements in later decades [1].

Trace elements released to the environment by minerals natural weathering and human different activities. The operations of smelting and mining are the main sources of soil contamination with trace elements. This contamination has negative effects on agricultural activities and all vital health near it [2].

Now the problem of environment contamination with trace elements took more attention. Dust released in industry areas is the major pathways of this contamination such as cement production. So soils are considered as the optimal sink for trace elements which spoiled to the environment. Trace elements are good indicators for monitoring environmental pollution sensitively [3].

Some trace elements in soils have reverse effect on plant growth, the other are toxic to human body. Dusts contamination with toxic trace elements cause accumulating these elements in plant tissue by absorption, then pass to human body via food chain. The other passing pathways are air inhalation and dermal contact [4].

Some of the trace elements are beneficial to humans and the environment, but some have biological toxic effects, depending on their sources, oxidation processes, and concentrations. Most trace elements are either human sources (mining and industrial activities) or natural. Trace elements coming from manufacturing processes are transferred to surface water, and then to groundwater, which is caused soil pollution and plants. Arsenic and nickel cause diseases of the nervous system, lung cancer and damage of the nasal barrier and skin. Cadmium causes blood, kidney and skeletal diseases. Chromium causes ulcers and respiratory diseases. Manganese, tin and mercury cause diseases of the nervous system. Lead causes diseases of the blood, kidneys and nervous system [5].

The correlation between pollution and economic growth in many countries is accompanied by increasing of emissions from different sources of human activities especially in urban communities such as increasing in transportation volume and population [6].

Industry areas have the great chance of contamination with heavy metal trace elements as a result of manufacturing processes. In these areas the harmful dust released to atmosphere and cause disease to human by inhalation and effect on vegetables growth which represent the main part of food chain. Harmful effects of trace elements on human's health including eye and skin irritation, less lungs function, allergy and cancer diseases. [7]

The serious trace elements presence in food chain is depending on their relative level. Cadmium is very toxic and cause kidney function, chromium and copper are also toxic cause nephritis, kidney extensive lesion and anuria [8].

The properties of soil effect on the allocation of trace elements on it by its important role of trace elements bioavailability and mobility [9].

The presence of trace elements continues for a long time in vitro because they do not degrade biologically [10].

Dust pollution with trace elements has become the main problem in Al-Shaibah area due to the presence of the oil refinery, military and electrical gas stations, so this study aims to analyze the contamination of trace elements concentrations (Cr, Cd, Ni and Pb) of dust fallen in nine stations in Al-Shaibah area in the south of Iraq, then determined the ecological risk of these trace elements using the potential ecological risk way suggested by (Hakanson). The (carcinogenic)and (non-carcinogenic) effects of (Cr, Cd, Ni and Pb) are also determined using the (United States Environmental Protection Agency (USEPA)) models and assumptions in order to prepare useful information about trace elements control and management of human health risk assessment in this city.

2. Study Area and Methodology

2.1 Study Area

Study area consists nine stations which nearby the oil refinery in Al-Shaibah area and areas around it as shown in Figure (1), in Basrah city southern of Iraq as in Table (1). Health risk and ecological risk assessments are based on human's health or living environment so these stations are good guidelines for analysis by their closeness to population and other parts of food chain. Data consists of concentrations of four trace elements: (1. chromium Cr, 2.cadmium Cd, 3.nickel Ni and 4.lead Pb) of dust fallen in Al-Shaibah area and areas around it between June 2011and November 2012 [11].

Table (1): Describing Stations of the Study Area.

Station	Describing
St1	Electric gas station
St2	Al-Shaibah houses
St3	House staff break
St4	Oil refinery
St5	FCC project
St6	Military control
St7	Al-Kassed station
St8	Alkziza stores
St9	Mazar Anas Ibn Malik

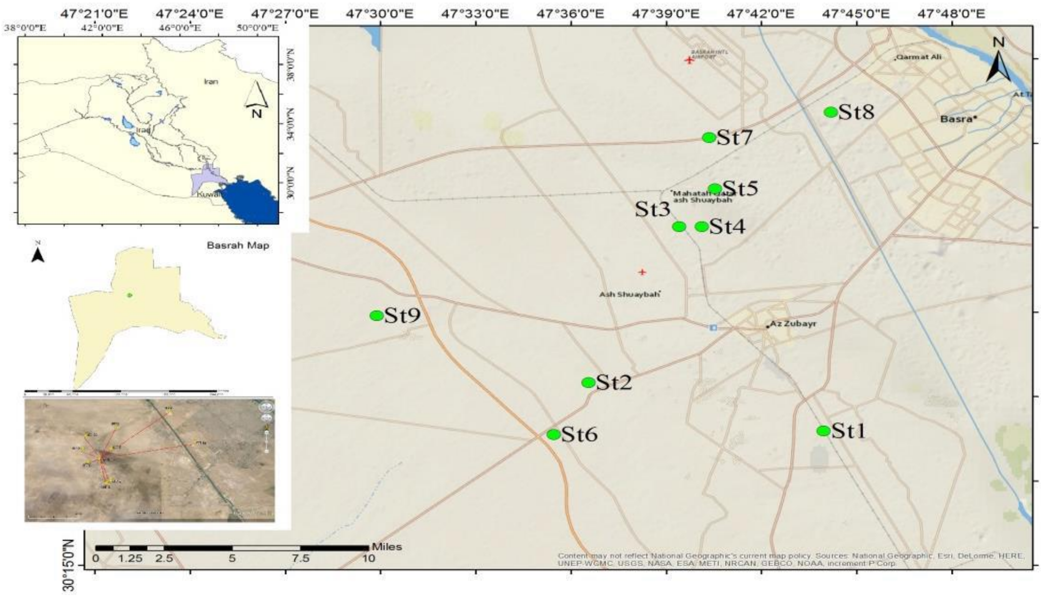

Figure (1): Study Area and Dust Sampling Locations in Basrah City [11].

2.2 Methodology

2.2.1 Assessment of Human Health Risk

The concentrations of trace elements (Cr, Cd, Ni and Pb) in study area dust were used to compute them health risk on residents. USEPA equations and assumptions were used to evaluate the chronic daily index CDI via three dust exposure ways: a.ingestion, b.inhalation and c.dermal (equations 1, 2 and 3 severally) as indicated in Table (2).

Table (2): Input Assumptions and Parameters of Health Risk Assessment.

Exposure Pathway	Exposure Equations	Equs. No.
Dust ingestion	$CDI_{ing} = \frac{CS * CF * IR * EF * ED}{(BW * AT)}$	…1[12,13]
Dust airborne inhalation	$CDI_{inhal} = \frac{CS * INHR * CF * EF * ED}{PEF * BW * AT}$	…2[2,14,13]
Dermal pathway	$CDI_{derm} = \frac{CS * SA * CF * ABS * AF * EF * ED}{(BW * AT)}$	…3[15]

Assumptions: [*CDI*: chronic daily intake (mg/(kg.day))], [*CS*: concentration of trace elements in dust (mg/kg)], [*CF*: conversion factor for soil (10^{-6} kg/mg)], [*IR*: ingestion rate of dust (100 mg/day)], [*EF*: exposure frequency (350 day/year or events/year)], [*ED*: exposure duration (30 year)], [*BW*: body weight (60.6 kg)], [*AT*: averaging time (days); for (non-carcinogenic): *ED* (years) * 365 days.year^{-1} and for (carcinogenic): 70 years * 365 days/years], [*INHR*: daily air inhalation rate (14.5 m^3/day)], [*PEF*: particle emission factor(1.36×10^9 m^3/kg)], [*SA*: skin surface area available for contact (5408 cm^2)], [*ABS*: absorption factor for dust contaminant (0.001)], [*AF*: dust-to-skin adherence factor (0.2 mg/cm)] [14].

The non-carcinogens and carcinogens impacts through (a.dust ingestion, b.inhalation and c.dermal contact) were evaluated using equations 4, 5, 6 and 7 as follows [1, 15, 16]:

$$HQ = CDI / RfD \quad \text{.........4}$$

$$HI = \sum HQ \quad \text{.........5}$$

$$CR = CDI * SF \quad \text{.........6}$$

$$TCR = \sum CR \quad \text{.........7}$$

Where *HQ*: (non-carcinogenic) hazard quotient, *HI*: accumulative hazard quotient (hazard index) of the trace elements, *CR:* carcinogenic risk, *TCR:* total carcinogenic risk of trace elements. *RfD*: reference dose for ingestion, inhalation and dermal dust exposure (mg/ (kg.day)), as shown in Table (3). *SF:* slop factor (mg/ (kg.day)) also listed in Table (3).

Table (3): *RfD* and *SF* for Trace Elements in Dust [2].

Parameter mg/(kg.day)	Cr	Cd	Ni	Pb
RfD_{ing}	$3*10^{-3**}$	$1*10^{-3}$	$2*10^{-2}$	$3.5*10^{-3}$
RfD_{inhal}	$3*10^{-5**}$	$1*10^{-5}$	$9*10^{-5}$	Not found
RfD_{derm}	$7.5*10^{-5*}$	$1*10^{-5}$	$5.4*10^{-3}$	$1.23*10^{-4}$
Sfing	$5*10^{-1**}$	15	Not found	$8.5*10^{-3}$
Sf_{inhal}	$4.1*10^{-1**}$	6.30	$8.4*10^{-1}$	$4.2*10^{-2**}$
Sf_{derm}	Not found	Not found	Not found	Not found

* [13], ** [17]

2.2.2 Assessment of Ecological Risk

Potential ecological risk method investigated by Hakanson to explain the toxic effect of trace elements on soil or dust and to evaluate the environmental ecological effects [3].

$$RI = \sum E_r^i \qquad ...8$$

$$E_r^i = T_r^i * C_f^i \qquad ...9$$

$$C_f^i = \frac{C^i}{C_n^i} \qquad ...10$$

$$C_{deg} = \sum C_f^i \qquad ...11$$

Where *RI* is the potential ecological risk, which measures the harmful effect of trace elements on environment including soil and dust, E_r^i is the individual potential ecological risk factor of the heavy metal. The grades of potential ecological risks indices are listed in Table (4).

Table (4): Risk Grades of *RI* and E_r^i [3].

E_r^i	Grade	*RI*	Grade
$E_r^i < 40$	Potential ecological risk is low	$RI < 90$	Potential ecological risk is low
$80 > E_r^i \geq 40$	Potential risk is moderate	$180 > RI \geq 90$	Potential ecological risk is moderate
$160 > E_r^i \geq 80$	Potential risk is considered	$360 > RI \geq 180$	Potential ecological risk is strong
$320 > E_r^i \geq 160$	Potential risk is high	$720 > RI \geq 360$	Potential is very strong
$E_r^i \geq 320$	Potential risk is very high	$RI \geq 720$	Potential is highly strong

T_r^i is the toxicity response coefficient of trace elements applied by Hakanson[3] listed in Table (5)). C^i is the concentration of trace element in dust (ppm), C_n^i is the reference values of the trace elements in soil/sediments, listed in Table (5). C_f^i is the pollution coefficient for each trace element, which shown in Table (6). C_{deg} is the integrated pollution level in the environment (accumulative value of C_f^i for all heavy meals) as indicated in Table (6).

Table (5): Toxicity Response Coefficient and Reference Values for Trace Elements [3].

Trace Elements	T_r^i	C_n^i
Cr	2	90
Cd	30	3
Ni	5	50
Pb	5	100

Table (6): Grades of Pollution Coefficient and Integrated Pollution Level for Trace Elements [9].

Index	Low Pollution	Middle Pollution	High Pollution	Very High Pollution
C_f^i	$C_f^i \leq 1$	$1 < C_f^i \leq 3$	$C_f^i > 3$	
C_{deg}	$C_{deg} < 5$	$5 \leq C_{deg} < 10$	$10 \leq C_{deg} < 20$	$C_{deg} \geq 20$

3. Result and Discussion

Trace elements concentrations in study site dust between June 2011 and November 2012 in nine stations are illustrated in Table (7).

Table (7): Mean and Standard Deviation of Trace Elements Concentrations between June 2011and November 2012 [11].

Station	Statistics	Cr(ppm)	Cd(ppm)	Ni(ppm)	Pb(ppm)
St1	Mean	3.46	0.08	1.42	16.05
	SD	2.02	0.09	0.03	34.98
St2	Mean	5.99	0.08	22.02	10.68
	SD	9.54	0.08	30.45	12.25
St3	Mean	2.00	0.01	0.06	4.16
	SD	1.07	0.01	-	5.66
St4	Mean	4.14	0.03	0.54	3.87
	SD	3.11	0.03	-	3.55
St5	Mean	1.40	0.03	5.14	2.06
	SD	0.91	0.04	-	0.70
St6	Mean	3.82	0.01	0.59	1.53
	SD	2.14	0.01	-	0.86
St7	Mean	2.66	0.02	1.46	1.53
	SD	1.77	0.02	0.44	0.63
St8	Mean	3.43	0.29	1.10	10.47
	SD	3.33	0.43	0.84	14.06
St9	Mean	5.05	0.10	1.01	9.73
	SD	3.10	0.08	0.98	9.39

Cr and Pb concentrations were dominated in all stations except St2 and St5 which have the highest concentrations for Cr and Pb. Chromium, cadmium and lead may be come from the nearest areas as well as the local contamination. Nickel founded in locallity polluted. The amounts of polluted dust is different form each station to another. The great amount of contamination with race elements belong to the oil refinery and the traffic load in this area [11].

3.1 Assessment of Health Risk

Non-carcinogenic and carcinogenic chronic daily intake for Cr, Cd, Ni and Pb in all stations are shown in Tables (8) and (9) through: a.ingestion, b.inhalation and c.dermal exposure routs. Table (10) explained the non-carcinogenic hazard quotient *HQ* for each trace elements via the three contact ways. The order non-carcinogenic hazard quotient for trace elements is Cr > Pb > Cd > Ni as shown in Figure (2). Then the total or accumulative non-carcinogenic hazard quotient *HI* is calculated. For all stations *HI*<1(Figure (3)), so there is no non-carcinogenic impact on human health according to USEPA standards [14] [18].

Table (8): Non-Carcinogenic Chronic Daily Intake of Heavy Metals via Three Different Exposure Routs.

Station	$CDI_{non-carcinogenic}(mg.kg^{-1}.day^{-1})$											
	Cr			Cd			Ni			Pb		
	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.
St1	$5.473*10^{-5}$	$5.837*10^{-15}$	$5.882*10^{-7}$	$1.266*10^{-6}$	$1.350*10^{-16}$	$1.360*10^{-8}$	$2.246*10^{-5}$	$2.396*10^{-15}$	$2.414*10^{-7}$	$2.539*10^{-4}$	$2.708*10^{-14}$	$2.729*10^{-6}$
St2	$9.476*10^{-5}$	$1.011*10^{-14}$	$1.018*10^{-6}$	$1.266*10^{-6}$	$1.350*10^{-16}$	$1.360*10^{-8}$	$3.484*10^{-4}$	$3.715*10^{-14}$	$3.743*10^{-6}$	$1.690*10^{-4}$	$1.802*10^{-14}$	$1.816*10^{-6}$
St3	$3.164*10^{-5}$	$3.374*10^{-15}$	$0.340*10^{-6}$	$1.582*10^{-7}$	$1.687*10^{-17}$	$1.700*10^{-9}$	$9.492*10^{-7}$	$1.012*10^{-16}$	$1.020*10^{-8}$	$6.581*10^{-5}$	$7.018*10^{-15}$	$7.072*10^{-7}$
St4	$6.549*10^{-5}$	$6.984*10^{-15}$	$7.038*10^{-7}$	$4.746*10^{-7}$	$5.061*10^{-17}$	$5.100*10^{-9}$	$8.543*10^{-6}$	$9.110*10^{-16}$	$9.180*10^{-8}$	$6.122*10^{-5}$	$6.529*10^{-15}$	$6.579*10^{-7}$
St5	$2.215*10^{-5}$	$2.362*10^{-15}$	$0.238*10^{-6}$	$4.746*10^{-7}$	$5.061*10^{-17}$	$5.100*10^{-9}$	$8.131*10^{-5}$	$8.671*10^{-15}$	$8.738*10^{-7}$	$3.259*10^{-5}$	$3.475*10^{-15}$	$3.502*10^{-7}$
St6	$6.043*10^{-5}$	$6.444*10^{-15}$	$6.494*10^{-7}$	$1.582*10^{-7}$	$1.687*10^{-17}$	$1.700*10^{-9}$	$9.334*10^{-6}$	$9.953*10^{-16}$	$1.003*10^{-7}$	$2.420*10^{-5}$	$2.581*10^{-15}$	$2.601*10^{-7}$
St7	$4.208*10^{-5}$	$4.487*10^{-15}$	$4.522*10^{-7}$	$3.164*10^{-7}$	$3.374*10^{-17}$	$3.400*10^{-9}$	$2.310*10^{-5}$	$2.463*10^{-15}$	$2.482*10^{-7}$	$2.420*10^{-5}$	$2.581*10^{-15}$	$2.601*10^{-7}$
St8	$5.426*10^{-5}$	$5.786*10^{-15}$	5.831E-07	$4.588*10^{-6}$	$4.892*10^{-16}$	$4.930*10^{-8}$	$1.740*10^{-5}$	$1.856*10^{-15}$	$1.870*10^{-7}$	$1.656*10^{-4}$	$1.766*10^{-14}$	$1.780*10^{-6}$
St9	$7.989*10^{-5}$	$8.519*10^{-15}$	8.585E-07	$1.582*10^{-6}$	$1.687*10^{-16}$	$1.700*10^{-7}$	$1.598*10^{-5}$	$1.704*10^{-15}$	$1.717*10^{-7}$	$1.539*10^{-4}$	$1.641*10^{-14}$	$1.654*10^{-6}$

Table (9): Carcinogenic Chronic Daily Intake of Heavy Metals via Three Different Exposure Routs.

Station	$CDI_{carcinogenic}(mg.kg^{-1}.day^{-1})$											
	Cr			Cd			Ni			Pb		
	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.	Ing.	Inhal.	Derm.
St1	$2.346*10^{-5}$	$2.502*10^{-15}$	$2.422*10^{-7}$	$5.424*10^{-7}$	$5.784*10^{-17}$	$5.600*10^{-9}$	$9.628*10^{-6}$	$1.027*10^{-15}$	$9.940*10^{-8}$	$10.882*10^{-4}$	$1.160*10^{-14}$	$1.124*10^{-6}$
St2	$4.061*10^{-5}$	$4.331*10^{-15}$	$4.193*10^{-7}$	$5.424*10^{-7}$	$5.784*10^{-17}$	$5.600*10^{-9}$	$1.493*10^{-4}$	$1.592*10^{-14}$	$1.541*10^{-6}$	$7.241*10^{-5}$	$7.722*10^{-15}$	$7.476*10^{-7}$
St3	$1.356*10^{-5}$	$1.446*10^{-15}$	$1.400*10^{-7}$	$6.780*10^{-8}$	$7.230*10^{-18}$	$7.000*10^{-10}$	$4.068*10^{-7}$	$4.338*10^{-17}$	$4.200*10^{-9}$	$2.820*10^{-5}$	$3.008*10^{-15}$	$2.912*10^{-7}$
St4	$2.807*10^{-5}$	$2.993*10^{-15}$	$2.898*10^{-7}$	$2.034*10^{-7}$	$2.169*10^{-17}$	$2.100*10^{-9}$	$3.661*10^{-6}$	$3.904*10^{-16}$	$3.780*10^{-8}$	$2.624*10^{-5}$	$2.798*10^{-15}$	$2.709*10^{-7}$
St5	$0.949*10^{-5}$	$1.012*10^{-15}$	$0.980*10^{-7}$	$2.034*10^{-7}$	$2.169*10^{-17}$	$2.100*10^{-9}$	$3.485*10^{-5}$	$3.716*10^{-15}$	$3.598*10^{-7}$	$1.397*10^{-5}$	$1.489*10^{-15}$	$1.442*10^{-7}$
St6	$2.590*10^{-5}$	$2.762*10^{-15}$	$2.674*10^{-7}$	$6.780*10^{-8}$	$7.230*10^{-18}$	$7.000*10^{-10}$	$4.000*10^{-6}$	$4.266*10^{-16}$	$4.130*10^{-8}$	$1.037*10^{-5}$	$1.106*10^{-15}$	$1.071*10^{-7}$
St7	$1.803*10^{-5}$	$1.923*10^{-15}$	$1.862*10^{-7}$	$1.356*10^{-7}$	$1.446*10^{-17}$	$1.400*10^{-9}$	$9.899*10^{-6}$	$1.056*10^{-15}$	$1.022*10^{-7}$	$1.037*10^{-5}$	$1.106*10^{-15}$	$1.071*10^{-7}$
St8	$2.326*10^{-5}$	$2.480*10^{-15}$	$2.401*10^{-7}$	$1.966*10^{-6}$	$2.097*10^{-16}$	$2.030*10^{-8}$	$7.458*10^{-6}$	$7.953*10^{-16}$	$0.770*10^{-8}$	$7.099*10^{-5}$	$7.570*10^{-15}$	$7.329*10^{-7}$
St9	$3.424*10^{-5}$	$3.651*10^{-15}$	$3.535*10^{-7}$	$6.780*10^{-7}$	$7.230*10^{-17}$	$0.700*10^{-8}$	$6.848*10^{-6}$	$7.302*10^{-16}$	$7.070*10^{-8}$	$6.597*10^{-5}$	$7.035*10^{-15}$	$6.811*10^{-7}$

Table (10): The Non-Carcinogenic Hazard Quotient for Trace Elements.

Station	$HQ = \sum [HQ_{ing} + HQ_{inhal} + HQ_{derm}]$				$HI = \sum HQ$
	Cr	Cd	Ni	Pb	
St1	0.097	0.015	0.00117	0.095	0.207
St2	0.167	0.015	0.01811	0.063	0.263
St3	0.056	0.002	$4.935*10^{-5}$	0.025	0.082
St4	0.116	0.006	0.00044	0.023	0.145
St5	0.039	0.006	0.00423	0.012	0.061
St6	0.107	0.002	0.00049	0.009	0.118
St7	0.074	0.004	0.00120	0.009	0.088
St8	0.096	0.054	0.00090	0.062	0.212
St9	0.141	0.019	0.00083	0.057	0.218

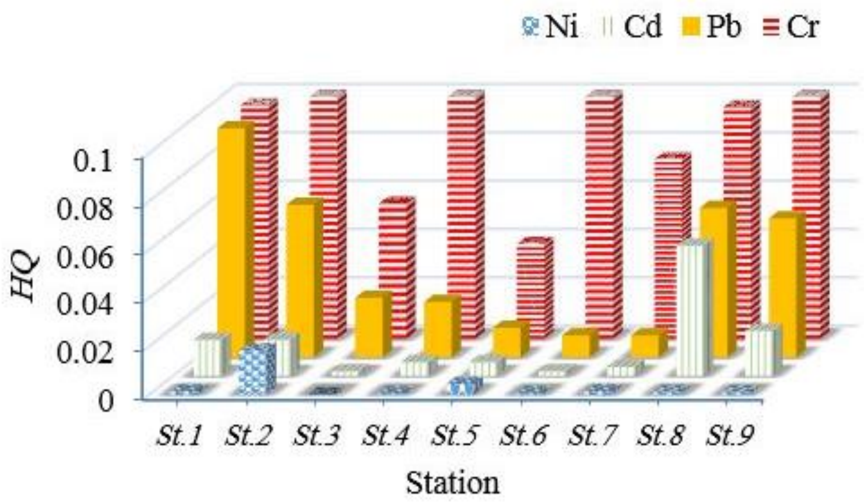

Figure (2): The Non-Carcinogenic Hazard Quotient for each Trace Element.

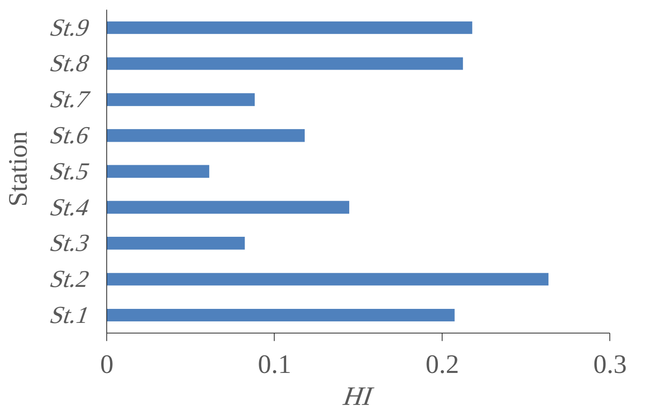

Figure (3): The Total Non-Carcinogenic Hazard Quotient for each Station.

The carcinogenic risk *CR* impact for each trace elements is listed in Table (11). The order of carcinogenic risk for trace elements is as follows Cr > Cd > Pb > Ni indicated in Figure (4), then the total carcinogenic risk *TCR* also determined. For all stations *TCR* is within the limit (10^{-4} – 10^{-6}) (Figure (5)) [19, 20]. Stations 1, 2, 8 and 9 have the maximum *HI* and *TCR* as indicated in Figures (3) and (5).

Table (11): The Carcinogenic Risk for Trace Elements.

Station	$CR = \sum [CR_{ing} + CR_{inhal}]$				$TCR = \sum CR$
	Cr	Cd	Ni	Pb	
St1	$1.173*10^{-5}$	$8.136*10^{-6}$	$8.624*10^{-16}$	$9.250*10^{-7}$	$2.079*10^{-5}$
St2	$2.031*10^{-5}$	$8.136*10^{-6}$	$1.337*10^{-14}$	$6.155*10^{-7}$	$2.906*10^{-5}$
St3	$6.780*10^{-6}$	$1.017*10^{-6}$	$3.644*10^{-17}$	$2.397*10^{-7}$	$8.037*10^{-6}$
St4	$1.403*10^{-5}$	$3.051*10^{-6}$	$3.280*10^{-16}$	$2.230*10^{-7}$	$1.731*10^{-5}$
St5	$4.746*10^{-6}$	$3.051*10^{-6}$	$3.122*10^{-15}$	$1.187*10^{-7}$	$7.916*10^{-6}$
St6	$1.295*10^{-5}$	$1.017*10^{-6}$	$3.583*10^{-16}$	$8.817*10^{-8}$	$1.406*10^{-5}$
St7	$9.017*10^{-6}$	$2.034*10^{-6}$	$8.867*10^{-16}$	$8.817*10^{-8}$	$1.114*10^{-5}$
St8	$1.163*10^{-5}$	$2.949*10^{-5}$	$6.681*10^{-16}$	$6.034*10^{-7}$	$4.172*10^{-5}$
St9	$1.712*10^{-5}$	$1.017*10^{-5}$	$6.134*10^{-16}$	$5.607*10*^{-7}$	$2.785*10^{-5}$

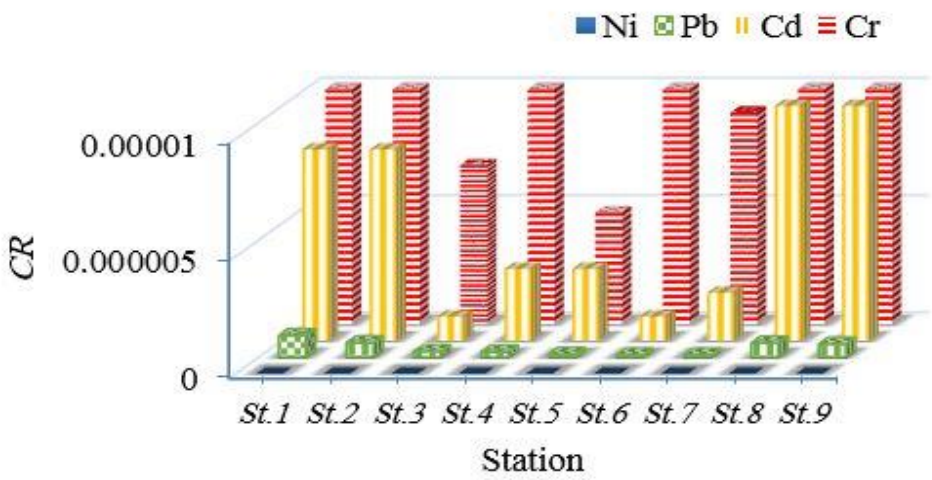

Figure (4): The Carcinogenic Risk for each Trace Element.

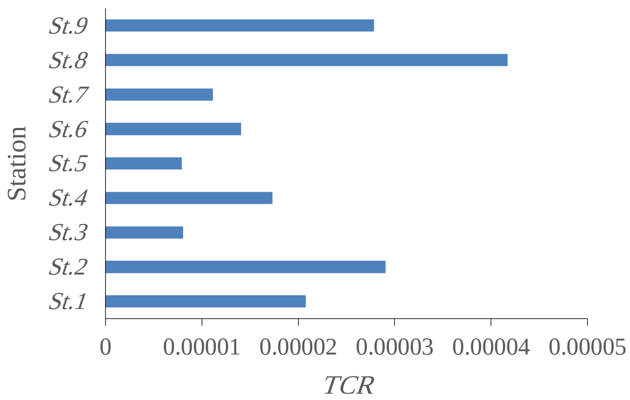

Figure (5): The Total Carcinogenic Risk for each Station.

3.2 Ecological Risk Assessment

The analysis of "ecological pollution" of trace elements is illustrated in Table (12). The integrated pollution level of trace elements in the environment C_{deg} for all stations are less than five which indicated low pollution level which also curtained by the *RI* calculated as it is less than ninety for all stations. This means that this area is low potential ecological risk. Order of trace elements are: Pb > Cd > Ni > Cr according to the ecological risk indices. Stations 1, 2, 8 and 9 have the maximum potential ecological risk and the "integrated pollution level" in the environment as indicated in Figures (6) and (7), this may be due to properties of dust particles such as weight and size, wind speed may also affect the distribution of these particles fallen in different places.

Table (12): Outcomes of Ecological Risk Assessment of Trace Elements.

Station	C_f^i				C_{deg}	E_r^i				*RI*
	Cr	Cd	Ni	Pb		Cr	Cd	Ni	Pb	
St1	0.038	0.027	0.028	0.161	0.254	0.077	0.800	0.142	0.803	1.821
St2	0.067	0.027	0.440	0.107	0.640	0.133	0.800	2.202	0.534	3.669
St3	0.022	0.003	0.001	0.042	0.068	0.044	0.100	0.006	0.208	0.358
St4	0.046	0.01	0.011	0.039	0.106	0.092	0.300	0.054	0.194	0.640
St5	0.016	0.01	0.103	0.021	0.149	0.031	0.300	0.514	0.103	0.948
St6	0.042	0.003	0.012	0.015	0.073	0.085	0.100	0.059	0.077	0.320
St7	0.030	0.007	0.029	0.015	0.081	0.059	0.200	0.146	0.077	0.482
St8	0.038	0.097	0.022	0.105	0.261	0.076	2.900	0.11	0.524	3.610
St9	0.056	0.033	0.020	0.097	0.207	0.112	1.00	0.101	0.487	1.700

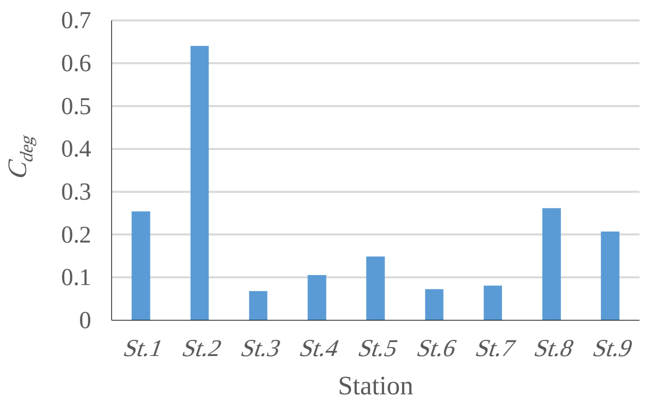

Figure (6): Distribution of the Integrated Pollution Level for Trace Elements in the Environment.

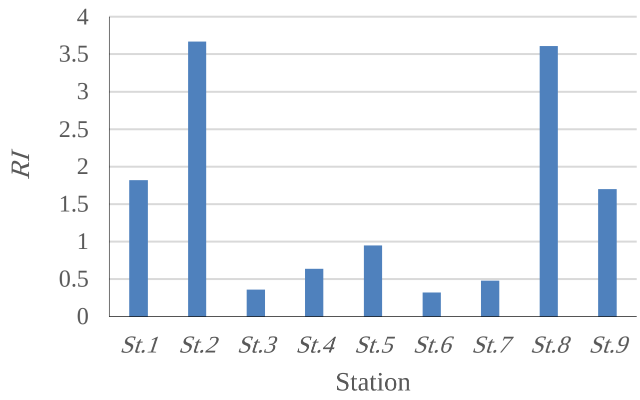

Figure (7): Potential Ecological Risk Distribution for Trace Elements in the Environment.

4. Conclusions

1. For all stations the non-carcinogenic order for trace elements in dust is: Cr > Pb > Cd > Ni through several pathways: a.ingestion, b.inhalation and c.dermal. The total or accumulative non-carcinogenic hazard quotient *HI* for all stations is less than unity, so there is no non-carcinogenic impact on human health according to USEPA standards.
2. For all stations carcinogenic risk order for trace elements in dust is: (Cr > Cd > Pb > Ni), the total carcinogenic risk *TCR* is within the limit ($10^{-4} – 10^{-6}$). Therefore, this area is safe for carcinogenic effect on human health.
3. Potential ecological risk order: (Pb > Cd > Ni > Cr), this study indicates that all trace elements (Cr, Cd, Ni and Pb) are clean and don't reach the level that contaminate the environment.

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تقييم المخاطر البيئية والصحية للعناصر النزرة في غبار الشعيبة، مدينة البصرة، العراق

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الخلاصة

الهدف من هذه الدراسة هو تقييم الأحمال الملوثة من الغبار الملوث الساقط في المناطق القريبة من مصفاة النفط في منطقة الشعيبة والمناطق المحيطة بها في البصرة بالعراق بين يونيو 2011 ونوفمبر 2012 في تسع محطات. العناصر النزرة في الغبار تحت الدراسة هي: الكرومCr، الكادميوم Cd، النيكل Ni والرصاص Pb. وتم حسب الاخذ اليومي المزمن *CDI* لهذه العناصر النزرة من خلال الابتلاع، والاستنشاق وتلامس الجلد وتم احتساب الاثر غير المسرطن *HI* والاثر الكلي المسرطن. **TCR** ترتيب العناصر النزرة في الغبار حسب الاثر غير المسرطن Cr > Pb > Cd > Ni. ترتيب العناصر النزرة في الغبار حمب الاثر المسرطن Cr > Cd > Pb > Ni. منطقة الدراسة آمنة من الخطرغير مسرطن والمسرطن على صحة الانسان. وأخيرا يتم تقييم المخاطر البيئية في اثنين من المؤشرات: مستوى التلوث المتكامل في البيئة C_{deg} والمخاطر البيئية المحتملة *RI*. ترتيب *RI* للعناصر النزرة هو: Pb > Cd > Ni > Cr، تشير هذه الدراسة إلى أن جميع المحطات تنطوي على مخاطر بيئية محتملة منخفضة.

الكلمات المفتاحية: الصحة البشرية، العناصر النزرة، الغبار، التعرض للمخاطر، المخاطر البيئية.