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Elemental Analysis of Total Suspended Particulates and PM_{10} in the Ambient Air of Lafarge Cement Syria and Ceramic (Fayhaa) Industry

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Determination of total suspended particulates and PM_{10} of aerodynamics particle sizes larger than 0.3 µm and heavy metals (Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn) by atomic absorption spectroscopy in the ambient air of Lafarge Cement Syria and Ceramic (Fayhaa) Industry were studied. The mean total suspended particulates and PM_{10} levels in ambient air Lafarge Cement Syria were at 98 to 156 and 49 to 99 µg m^{-3}, respectively and in ambient air Ceramic (Fayhaa) Industry were at 318 to 368 and 209 to 215 µg m^{-3}, respectively. The above mentioned heavy metal concentrations were at 1.2 to 1.4 and 0.52 to 0.65; 0.00048 to 0.00062 and 0.00036 to 0.00047; 0.60 to 0.76 and 0.43 to 0.47; 0.092 to 0.12 and 0.081 to 0.085; 0.00017 to 0.00029 and 0.00015 to 0.00027; 2.8 to 11.1 and 2.2 to 2.9; 0.13 to 0.19 and 0.067 to 0.072; 0.094 to 0.148 and 0.065 to 0.082 µg m^{-3} in ambient air of Lafarge Cement Syria using total suspended particulates and PM_{10}, respectively and in ambient air of Ceramic (Fayhaa) Industry were at 0.92 to 1.07 and 0.59 to 0.66; 0.00056 to 0.00080 and 0.00048 to 0.00076; 0.52 to 0.69 and 0.10 to 0.14; 0.047 to 0.051 and 0.031 to 0.046; 0.00038 to 0.00045 and 0.00021 to 0.00028; 2.38 to 6.42 and 1.09 to 3.27; 0.053 to 0.086 and 0.048 to 0.078; 0.153 to 0.159 and 0.114 to 0.155 µg m^{-3} using total suspended particulates and PM_{10}, respectively. The results showed that the values of Pb, Mn and Fe in Lafarge Cement Syria atmosphere and total suspended particulates, PM_{10}, Pb and Fe in ceramic (Fayhaa) industry atmosphere were more than the recommended maximum by World Health Organization, while the value levels of all metals were lower than the guideline values specified by World Health Organization .

Key Words: Airborne particulates, Heavy metals, Lafarge cement, Ceramic industry.

INTRODUCTION

Sampling dust and particulate matter is important as dust and particulate matter can affect the health of human populations, as well as the natural environment. Dust and particulate matter can cause respiratory problems when breathed in by humans. Dust and particulates above 10 µm are filtered and generally do not enter the lungs. Dust and particulates below PM_{10} are likely to enter the lungs. Dust and particulate matter that is smaller than 2.5 µm ($PM_{2.5}$) can enter into the Alveoli where gas exchange occurs. This $PM_{2.5}$ is more dangerous as it can affect the exchange of gases within the lungs and even penetrate the lung into the blood stream and cause other health issues. These two size classes (PM_{10} and $PM_{2.5}$) are the normal sampling standards found throughout the world, they represent the particulate pollution that effects human health and thus sampling them provides an accurate insight into how dust and particulate matter at both PM_{10} and $PM_{2.5}$ effect human health. Atmospheric particulate pollution has imposed a great burden on the terrestrial environment on a regional scale and even in a global context. Epidemiological studies have indicated that elevated concentrations of fine-particulate matter are associated with increased mortality and morbidity, especially in children and elderly people. Heavy metals are non-degradable and can accumulate in the human body system, causing damage to a person's nervous system and internal organs. They also act as confounding factors of cardiovascular diseases, reproductive impairments and cancer[1-5].

Heavy metal and trace element concentrations were examined in topsoil's to evaluate a cement plant and an industrial waste incinerator as pollution sources. As, Ba, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, K, La, Lu, Na, Nd, Rb, Sb, Sc, Se, Sm, Ta, Tb, Th, U, Yb and Zn were measured by neutron activation analysis (NAA) and Co, Cu, Fe, Ni, Pb and Zn by a 0.5 M HCl extraction technique using an atomic absorption spectrophotometer (AAS). Total concentration of Cr and HCl-extracted Co and Mn were possibly related to wind transportation from an industrial area in the north of Córdoba city (Argentina). Cu, Pb and Zn in partial HCl extraction were influenced by the cement plant and the industrial area in the north of Córdoba city. The mean total Ba concentration was above the residential and agricultural land use limits stated in national and international legislation and was related to the distance to the cement plant. The concentrations of HCl-extracted heavy metals could

be predicted by the organic matter percentage and the distance to the cement plant (with R2 values of 0.50-0.74). Total concentration of Ca was seen to have little influence whereas the organic matter percentage strongly affected HCl-extracted heavy metals according to the correlation analysis and multiple regression models. According to soil quality guidelines for environmental health, the human and wildlife populations in Yocsina might be experiencing toxic Ba and Cr effects[6].

It is well known that ceramic clusters suffer from considerable air pollution due to the different pollutants into the atmosphere, whose levels can be toxic. Castellon province is home of the biggest nucleus of ceramic production in Spain, comprising 93 % of the country's total production. This nucleus, located around the cities of Castellon, Vila-real, Alcora and Onda, has had an important process of industrial expansion. The emissions, most of them particulate matter, can constitute a real environmental problem. The following objectives are raised: i) The analysis of the temporal evolution of the levels of As, Cd, Ni and PM_{10} in the atmosphere; ii) The identification of similar behaviour patterns and of the possible common origins in the studied pollutants; iii) To show the existence of differences in the behaviour and evolution of As, Cd, Ni and PM_{10} in the atmospheric medium depending on the location of the sampling point; and iv) To determine As, Cd, Ni and PM_{10} content in five topsoils near the emission focus and their biodisponibility. The concentration levels of As, Cd and Ni in Alcora, Vila-real and Castellon have been determined for the year 2002 in order to check whether they fall below the limits established for the future directive regarding these elements[7].

Environmental and biological monitoring of lead in acid batteries and liquid gases in Aleppo-Syrian company using total suspended particulates of aerodynamics particle sizes larger than 0.3 μm and chemical trap for total lead in air were studied. The results showed that, high mean of lead concentration in air in all different sections of the factory were more than the recommended maximum by National Ambient Air Quality Standards (NAAQS)[8,9]. Determination of Al, Cu and Pb in Aleppo company for cable industry-Syria using total suspended particulates and PM_{10} of aerodynamics particle sizes larger 0.3 μm and chemical trap were studied. The results showed that, the values of total suspended particulates, PM_{10}, Al and Cu in working atmosphere much lower than the guideline values specified by the Occupational Safety and Health Administration (OSHA)[10], while high levels of lead were more than the recommended maximum by OSHA[10] due to the fact that lead acid batteries and liquid gases plant adjacent to this factory from the western side and the wind direction often from west to east[11].

Determination of total suspended particulates and PM_{10} of aerodynamics particle sizes larger 0.3 μm and heavy metals (Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn) by atomic absorption spectroscopy in Aleppo city, Syria were studied. The mean total suspended particulates and PM_{10} levels in residential sites were at 73 to 241 and 37 to 110 $\mu g/m^3$, respectively and 256 to 961 and 123 to 585 $\mu g/m^3$ in industrial-residential sites, respectively. The above mentioned heavy metal concentrations were at 297 to 1112 and 201 to 734; 0.97 to 4.73 and 0.41 to 2.46; 312 to 1837 and 158 to 963; 68 to 223 and 33 to 120; 0.28 to 1.87 and 0.17 to 1.22; 1116 to 4604 and 780 to 2538; 179 to 270 and 113 to 170; 370 to 1039 and 240 to 710 ng/m^3 in industrial-residential sites using total suspended particulates and PM_{10}, respectively. The results showed that, the values of total suspended particulates, PM_{10}, Pb, Ni and Mn in industrial-residential sites atmosphere were more than the recommended maximum by World Health Organization (WHO)[12], while the value levels of all metals in residential sites were lower than the guideline values specified by WHO[13] (The recommended maximum by WHO as the followas: 0.5, 0.005,100, 1.1, 0.00038, 3.72, 0.150 and 5000 $\mu g/m^3$; total suspended particulates and PM_{10} 120 and 70, 240 and 100 in residential and industrial sites respectively).

Speciation of three trace elements (Zn, Pb, Cu) in air particulates of two Syrian cities (Tartous and Darya) with different climate conditions and industrial emissions has been studied. Air filters were collected during 2000-2001 and extracted chemically using different selective fluids in an attempt to identify the different forms of trace elements. Differences in chemical forms (organic and nonorganic) of the studied trace elements in air particulates were found to be related to differences in air pollution sources and differences in human behaviour throughout the year. Therefore, chemical fractionation of trace elements in air particulates using sequential leaching can be used for identification of air pollutions sources in urban and industrial areas[14].

In the present study, total suspended particulates and PM_{10} of aerodynamics particle sizes larger 0.3 μm and metal composition (Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn) in the ambient air of Lafarge Cement Syria (LCS) and Ceramic (Fayhaa) Industry (CFI) in north Syria (Aleppo) were studied.

EXPERIMENTAL

A high flow total suspended particulates air sampler system (HVAS, Instrument NO. AS-16, USA) and TE-6070 high volume MFC PM-10 MFC monitor reference method (TISCH Environmental, INC. 145 MIAMI AVE USA) were used to collect samples for 24 h using a glass filter Whatman EPM 2000 High-Volume 1882-866 and Micro-Quartz filter media 8" × 10" for total suspended particulates and PM_{10} respectively. Atomic absorption spectrometer used for analysis was manufactured by Shimadzu type AA-6601G equipped with lamps type HCL particular of analysis studied elements and corrected for background reference BGC-D_2K with flame (Air-C_2H_2) and flameless with graphite furnace (GF AAS). The analytical used line of Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn were at 217.0, 228.8, 324.75, 357.87, 232.0, 248.33, 279.48 and 213.86 nm respectively.

$Pb(NO_3)_2$, $CdCl_2.3H_2O$, $CuCl_2.2H_2O$, $CrCl_3.2H_2O$, $NiCl_2.2H_2O$, $FeCl_3.6H_2O$, $MnCl_2.2H_2O$, $ZnCl_2.2H_2O$, HNO_3 (65 %) and H_2O_2 (35 %) were purchased from Merck (extra pure).

Samples preparation: Samples were taken from western, eastern and southern (Lafarge Cement Syria) and northern and eastern [Ceramic(Fayhae)Inudustry] for determination of total suspended particulates, PM_{10}, Pb, Cd, Cu, Cr, Ni, Fe, Mn and

TABLE-1
PARTICULATE ELEMENT CONCENTRATION IN ATMOSPHERE OF WEST LAFARGE CEMENT SYRIA (LCS) USING TSP AND PM_{10}

Element	In TSP or PM_{10}*	$\bar{x}$ * ($\mu g\ m^{-3}$)	SD, ($\mu g\ m^{-3}$)	$\frac{SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	$\bar{x} \pm \frac{t.SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	RSD (%)
Pb	TSP	0.0041	0.00021	0.000093	0.0041 ± 0.00026	5.1
	PM_{10}	0.0030	0.00016	0.000070	0.0030 ± 0.00019	5.2
Cd	TSP	0.00020	0.0000072	0.0000032	0.00020 ± 0.0000089	3.6
	PM_{10}	0.00012	0.0000047	0.0000021	0.00012 ± 0.0000058	3.9
Cu	TSP	0.052	0.00125	0.00056	0.052 ± 0.00155	2.4
	PM_{10}	0.034	0.00088	0.0004	0.034 ± 0.0011	2.6
Cr	TSP	0.0062	0.0003	0.00013	0.0062 ± 0.00037	4.8
	PM_{10}	0.0051	0.00025	0.00011	0.0015 ± 0.00032	5.0
Ni	TSP	0.00013	0.0000070	0.0000031	0.00013 ± 0.0000087	5.4
	PM_{10}	0.00010	0.0000055	0.0000024	0.00010 ± 0.0000068	5.5
Fe	TSP	1.21	0.0254	0.0113	1.21 ± 0.0315	2.1
	PM_{10}	0.45	0.0112	0.005	0.45 ± 0.014	2.5
Mn	TSP	0.038	0.00156	0.0007	0.038 ± 0.0019	4.1
	PM_{10}	0.009	0.0004	0.00017	0.009 ± 0.00049	4.4
Zn	TSP	0.043	0.00133	0.00059	0.043 ± 0.00165	3.1
	PM_{10}	0.031	0.00099	0.00044	0.031 ± 0.00123	3.2

*n = 5, t = 2.776, Standard deviation (SD), Analytical standard error (SD/ $\sqrt{n}$), Confidence limit ($\bar{x}$ ± t.SD/ $\sqrt{n}$)

Zn pollutants. Samples were collected using the total suspended particulates and PM_{10}, dried at 105 ºC, followed by crushing in a porcelain mortar, then dried again and mixed once again and kept in polyethylene packages for next procedures. A 0.5 g of the previous sample was treated with 20 mL solution content HNO_3 and H_2O_2 (5 M) concentrations. The mixture was boiled on an electric heater for 0.5 h then filtrated and transferred into volumetric flask volume of 25 mL and the final volume was completed to 25 mL using distilled water.

Total suspended particulates monitoring: The total suspended particulates samples were collected continuously in the mentioned sites of Lafarge Cement Syria and Ceramic(Fayhae)Inudustry. The particulate collected using filters with a pore size of 0.3 μm.

Inhaled particulates PM_{10}: The inhaled particulates were measured using PM_{10} sampler in the different sites of Lafarge Cement Syria and [Ceramic(Fayhae)Inudustry]. Inhaled dust is a new term used to describe dust that is hazardous when they deposited anywhere in the respiratory track including the nose, mouth and lungs. Researchers generally recognize that these particulates <10 μm and > 0.3 μm may cause significant adverse effects.

Air-elements (Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn) estimation: The Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn contents in the total suspended particulates and PM_{10} samples were subjected to wet mixture digestion on a slow heating hot plate. The digested matter was filtered, made up to 25 mL using double distilled water. The final analysis for Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn estimation were performed by flame (Air-C_2H_2) and flameless with graphite furnace (GF AAS).

RESULTS AND DISCUSSION

Environmental monitoring: In the present study, personal monitoring of the total suspended particulates, PM_{10} were carried out in the ambient air of Lafarge Cement Syria (LCS) and Ceramic (Fayhaa) Industry (CFI). The levels of air elements (Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn) in atmosphere using total suspended particulates and PM_{10} were studied as the followas:

West of Lafarge Cement Syria: The mean western values (V_{west}) of total suspended particulates and PM_{10} were at 147 and 68 $\mu g\ m^{-3}$ respectively and air elements Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn concentrations were at 0.0041 and 0.0030; 0.00020 and 0.00012; 0.052 and 0.034; 0.0062 and 0.0051; 0.00013 and 0.00010; 1.21 and 0.45; 0.038 and 0.009; 0.043 and 0.031 $\mu g\ m^{-3}$ using total suspended particulates and PM_{10} respectively (wind direction south-east). The sequence for heavy metal concentrations in ambient air were Fe > Cu > Zn > Mn > Cr > Pb > Cd > Ni. The concentration of heavy metals Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn relative to the total suspended particulates and PM_{10} were at 0.0028 and 0.0044 %; 0.00014 and 0.00017 %; 0.035 and 0.050 %; 0.0042 and 0.0075 %; 0.000088 and 0.000147 %; 0.82 and 0.66 %; 0.026 and 0.0132 %; 0.029 and 0.045 % respectively (Table-1).

East of Lafarge Cement Syria: The mean net values ($V_{net} = V_{total} - V_{west}$) of total suspended particulates and PM_{10} were at 98 and 49 $\mu g\ m^{-3}$ respectively and air elements Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn concentrations were at 1.2 and 0.52; 0.00048 and 0.00036; 0.60 and 0.43; 0.092 and 0.081; 0.00017 and 0.00015; 2.8 and 2.2; 0.13 and 0.067; 0.094 and 0.065 $\mu g\ m^{-3}$ using total suspended particulates and PM_{10} respectively. The sequence for heavy metal concentrations in ambient air were Fe > Pb > Cu > Mn > Zn > Cr > Cd > Ni. The concentration of heavy metals Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn relative to the total suspended particulates and PM_{10} were at 1.22 and 1.06 %; 0.00049 and 0.00073 %; 0.61 and 0.88 %; 0.094 and 0.165 %; 0.00017 and 0.00031 %; 2.86 and 4.49 %; 0.13 and 0.14 %; 0.096 and 0.133 % respectively, Table-2. This site contains the highest quantity of Fe and Pb more than the recommended maximum by WHO.

South of Lafarge Cement Syria: The mean net values of total suspended particulates and PM_{10} were at 156 and 99 $\mu g\ m^{-3}$ respectively and air elements Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn concentrations were at 1.40 and 0.65; 0.00062

TABLE-2
PARTICULATE ELEMENT CONCENTRATION IN ATMOSPHERE OF EAST LAFARGE CEMENT SYRIA (LCS) USING TSP AND PM_{10}

Element	In TSP or PM_{10} *	$\bar{x}$ * ($\mu g\ m^{-3}$)	SD, ($\mu g\ m^{-3}$)	$\frac{SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	$\bar{x} \pm \frac{t.SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	RSD (%)
Pb	TSP	1.20	0.046	0.020	1.20 ± 0.057	3.8
	PM_{10}	0.52	0.021	0.0093	0.52 ± 0.026	4.0
Cd	TSP	0.00048	0.000017	0.0000075	0.00048 ± 0.000021	3.5
	PM_{10}	0.00036	0.000013	0.0000061	0.00036 ± 0.000017	3.8
Cu	TSP	0.60	0.013	0.0059	0.60 ± 0.016	2.2
	PM_{10}	0.43	0.0099	0.0044	0.43 ± 0.0122	2.3
Cr	TSP	0.092	0.0038	0.0017	0.092 ± 0.0047	4.1
	PM_{10}	0.081	0.0034	0.0051	0.081 ± 0.0042	4.2
Ni	TSP	0.00017	0.0000090	0.0000040	0.00017 ± 0.000011	5.3
	PM_{10}	0.00015	0.0000081	0.0000036	0.00051 ± 0.00001	5.4
Fe	TSP	2.80	0.056	0.025	2.80 ± 0.07	2.0
	PM_{10}	2.20	0.05	0.021	2.20 ± 0.06	2.2
Mn	TSP	0.13	0.0042	0.0018	0.13 ± 0.0052	3.2
	PM_{10}	0.067	0.0022	0.00099	0.067 ± 0.0027	3.3
Zn	TSP	0.094	0.0028	0.0012	0.094 ± 0.0035	3.0
	PM_{10}	0.065	0.002	0.0009	0.065 ± 0.0025	3.1

* n = 5, t = 2.776

TABLE-3
PARTICULATE ELEMENT CONCENTRATION IN ATMOSPHERE OF SOUTH LAFARGE CEMENT SYRIA (LCS) USING TSP AND PM_{10}

Element	In TSP or PM_{10} *	$\bar{x}$ * ($\mu g\ m^{-3}$)	SD, ($\mu g\ m^{-3}$)	$\frac{SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	$\bar{x} \pm \frac{t.SD}{\sqrt{n}}$ ($\mu g\ m^{-3}$)	RSD (%)
Pb	TSP	1.40	0.052	0.023	1.40 ± 0.064	3.7
	PM_{10}	0.65	0.025	0.011	0.65 ± 0.031	3.9
Cd	TSP	0.00062	0.000022	0.0000097	0.00062 ± 0.000027	3.5
	PM_{10}	0.00047	0.000018	0.000008	0.00047 ± 0.000022	3.8
Cu	TSP	0.76	0.017	0.0075	0.76 ± 0.021	2.2
	PM_{10}	0.47	0.011	0.0048	0.47 ± 0.013	2.3
Cr	TSP	0.12	0.0048	0.0021	0.12 ± 0.006	4.0
	PM_{10}	0.085	0.0036	0.0016	0.085 ± 0.0044	4.2
Ni	TSP	0.00029	0.000015	0.0000067	0.00029 ± 0.000019	5.2
	PM_{10}	0.00027	0.000014	0.0000064	0.00027 ± 0.000018	5.3
Fe	TSP	11.1	0.199	0.09	11.1 ± 0.25	1.8
	PM_{10}	2.9	0.064	0.028	2.9 ± 0.08	2.2
Mn	TSP	0.19	0.0057	0.0025	0.19 ± 0.007	3.0
	PM_{10}	0.072	0.0023	0.001	0.072 ± 0.0029	3.2
Zn	TSP	0.148	0.0043	0.0019	0.148 ± 0.0053	2.9
	PM_{10}	0.082	0.0025	0.0011	0.082 ± 0.003	3.0

*n = 5, t = 2.776

and 0.00047; 0.76 and 0.47; 0.12 and 0.085; 0.00029 and 0.00027; 11.1 and 2.9; 0.19 and 0.072; 0.148 and 0.082 $\mu g\ m^{-3}$ using total suspended particulates and PM_{10} respectively (wind direction north-east). The sequence for heavy metal concentrations in ambient air were Fe > Pb > Cu > Mn > Zn > Cr > Cd > Ni. The concentration of heavy metals Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn relative to the total suspended particulates and PM_{10} were at 0.90 and 0.66 %; 0.00040 and 0.00047 %; 0.49 and 0.47 %; 0.077 and 0.086 %; 0.00019 and 0.00027 %; 7.12 and 2.93 %; 0.12 and 0.073 %; 0.095 and 0.083 % respectively, Tables-3. This site contains the highest quantity of Fe, Pb and Mn more than the recommended maximum by WHO.

East of Ceramic (Fayhaa) industry (CFI): The mean values of total suspended particulates and PM_{10} were at 368 and 215 $\mu g\ m^{-3}$ respectively and air elements Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn concentrations were at 1.07 and 0.66; 0.00080 and 0.00076; 0.69 and 0.14; 0.051 and 0.046; 0.00045 and 0.00028; 6.42 and 3.27; 0.086 and 0.078; 0.159 and 0.155 $\mu g\ m^{-3}$ using total suspended particulates and PM_{10} respectively (wind direction north-east). The sequence for heavy metal concentrations in ambient air were Fe > Pb > Cu > Zn > Mn > Cr > Cd > Ni. The concentration of heavy metals Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn relative to the total suspended particulates and PM_{10} were at 0.29 and 0.31 %; 0.00022 and 0.00035 %; 0.19 and 0.065 %; 0.014 and 0.021 %; 0.00012 and 0.00013 %; 1.74 and 1.52 %; 0.023 and 0.036 %; 0.043 and 0.072 % respectively, Table-4. This site contains the highest quantity of total suspended particulates, PM_{10}, Fe, Pb and Ni more than the recommended maximum by WHO.

North of Ceramic(Fayhae)Inudustry: The mean values of TSP and PM_{10} were at 318 and 209 $\mu g\ m^{-3}$ respectively and air elements Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn

TABLE -4
PARTICULATE ELEMENT CONCENTRATION IN ATMOSPHERE OF EAST CERAMIC (FAYHAA) INDUSTRY USING TSP AND PM_{10}

Element	In TSP or PM_{10}*	$\bar{x}$ *, (μg m^{-3})	SD (μg m^{-3})	$\frac{SD}{\sqrt{n}}$ (μg m^{-3})	$\bar{x} \pm \frac{t.SD}{\sqrt{n}}$ (μg m^{-3})	RSD (%)
Pb	TSP	1.07	0.041	0.018	1.07 ± 0.050	3.8
	PM_{10}	0.66	0.026	0.011	0.66 ± 0.032	3.9
Cd	TSP	0.00080	0.000027	0.000012	0.00080 ± 0.000034	3.4
	PM_{10}	0.00076	0.000026	0.000012	0.00076 ± 0.000032	3.4
Cu	TSP	0.69	0.014	0.0065	0.69 ± 0.018	2.1
	PM_{10}	0.14	0.0035	0.0016	0.14 ± 0.0043	2.5
Cr	TSP	0.051	0.0022	0.00098	0.051 ± 0.0027	4.3
	PM_{10}	0.046	0.002	0.00091	0.046 ± 0.0025	4.4
Ni	TSP	0.00045	0.000023	0.000010	0.00045 ± 0.000029	5.2
	PM_{10}	0.00028	0.000015	0.0000066	0.00028 ± 0.000018	5.3
Fe	TSP	6.42	0.13	0.057	6.42 ± 0.16	2.0
	PM_{10}	3.27	0.07	0.031	3.27 ± 0.085	2.1
Mn	TSP	0.086	0.0027	0.0012	0.086 ± 0.0033	3.1
	PM_{10}	0.078	0.0024	0.0011	0.078 ± 0.0030	3.1
Zn	TSP	0.159	0.0044	0.002	0.159 ± 0.0055	2.8
	PM_{10}	0.155	0.0043	0.0019	0.155 ± 0.0054	2.8

*n = 5, t = 2.776

TABLE-5
PARTICULATE ELEMENT CONCENTRATION IN ATMOSPHERE OF NORTH CERAMIC (FAYHAA) INDUSTRY USING TSP AND PM_{10}

Element	In TSP or PM_{10}*	$\bar{X}$ *, (μg m^{-3})	SD, (μg m^{-3})	$\frac{SD}{\sqrt{n}}$, (μg m^{-3})	$\bar{x} \pm \frac{t.SD}{\sqrt{n}}$ (μ g m^{-3})	RSD (%)
Pb	TSP	0.92	0.036	0.016	0.92 ± 0.044	3.9
	PM_{10}	0.59	0.023	0.010	0.59 ± 0.028	3.9
Cd	TSP	0.00056	0.00002	0.000009	0.00056 ± 0.000024	3.5
	PM_{10}	0.00048	0.000017	0.000008	0.00048 ± 0.000021	3.6
Cu	TSP	0.52	0.011	0.0051	0.52 ± 0.014	2.2
	PM_{10}	0.10	0.0025	0.0011	0.10 ± 0.0031	2.5
Cr	TSP	0.047	0.0020	0.0009	0.047 ± 0.0025	4.3
	PM_{10}	0.031	0.0014	0.00061	0.031 ± 0.0017	4.4
Ni	TSP	0.00038	0.000020	0.0000090	0.00038 ± 0.000025	5.3
	PM_{10}	0.00021	0.000011	0.0000051	0.00021 ± 0.000014	5.4
Fe	TSP	2.38	0.05	0.022	2.38 ± 0.062	2.1
	PM_{10}	1.09	0.024	0.011	1.09 ± 0.03	2.2
Mn	TSP	0.053	0.0017	0.00076	0.053 ± 0.0021	3.2
	PM_{10}	0.048	0.0016	0.00071	0.048 ± 0.002	3.3
Zn	TSP	0.153	0.0043	0.002	0.153 ± 0.0053	2.8
	PM_{10}	0.114	0.0033	0.0015	0.114 ± 0.0041	2.9

*n = 5, t = 2.776

concentrations were at 0.92 and 0.59; 0.00056 and 0.00048; 0.52 and 0.10; 0.047 and 0.031; 0.00038 and 0.00021; 2.38 and 1.09; 0.053 and 0.048; 0.153 and 0.114 μg m^{-3} using total suspended particulates and PM_{10} respectively. The sequence for heavy metal concentrations in ambient air were Fe > Pb > Cu > Zn > Mn > Cr > Cd > Ni. The concentration of heavy metals Pb, Cd, Cu, Cr, Ni, Fe, Mn and Zn relative to the total suspended particulates and PM_{10} were at 0.29 and 0.28 %; 0.00018 and 0.00023 %; 0.16 and 0.048 %; 0.0148 and 0.0148%; 0.000119 and 0.00010%; 0.75 and 0.52 %; 0.017 and 0.023 %; 0.048 and 0.054 % respectively, Table-5. This site contains the highest quantity of total suspended particulates, PM_{10}, Fe, Pb and Ni more than the recommended maximum by WHO.

Conclusion

The results in this study showed that, the values of Pb, Mn and Fe in Lafarge Cement Syria (LCS) atmosphere and TSP, PM_{10}, Pb, Fe and Ni in Ceramic (Fayhaa) Industry (LCS) atmosphere were more than the recommended maximum by World Health Organization, while the value levels of all metals were lower than the guideline values specified by World Health Organization.

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