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Polycyclic Aromatic Hydrocarbons (PAHs) in the Soil of West Qurna-2 Oil Field Southern Iraq

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AbstractThis study focused on the determinate concentrations of polycyclic aromatic hydrocarbon by using capillary gas chromatographic for soil of ten stations in West Qurna-2 oil field. The first included light (low molecular weight) compounds with two-three fused aromatic rings which consisting of: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, and carbazole. The second included the heavy (high molecular weight) compounds with four or more fused aromatic rings consisting of: floranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)flouranthene, benzo(k)flouranthene, benzo(a)pyrene, indeno(1,2,3,c,d)pyrene,dibenzo(a,h)anthracene,andbenzo(g,h,i)perylene.The dominant light PAHs compoundswere acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene and carbazol. Whereas the dominant heavy PAHs compounds were floranthene, pyrene, benzo(a)pyrene**,** benzo(a)anthracene**,** benzo(k)flouranthene. The regional higher mean concentrations of PAHs in station 10was (5.906 ng/g) and the lowest in station 1(1.125 ng/g). The results of seasonal PAHs concentration in this study showed that the lowest concentrations recorded during summer (1.214 ng/g), while the highest concentrations recorded during winter (4.177ng/g). From the LMW/HMW, phenanthrene/anthraceneand benzo(a)anthracene/benzo(a)anthracene+ chrysene ratios, the PAHs compound was drived from pyrogenic sources, while Flouranthene/PyreneRatio and InP/(InP+BghiP) Ratio was pyrogenic+ petrogenic origin and petrogenic or pyrogenic and Ant/(Ant+ Phen) Ratio was pyrolytic. Concentrations in studied stations gradually increased from station 1 to station 5, and then significantly decreased at station 6 and finally increased to station 10. The fluctuation in concentrations of compound at stations is due to distance from the flame of the flare which near to the stations 8,9,10 and far to the stations 1,2,3,4,5,6,7, while the seasonal concentration arrange as following: winter >spring >autumn>summer.

There were non-significant correlation between the PAHs in soil and each of the soil texture compounds (sand, silt and clay), while there is significant correlation between the PAHs in soil and TOC%.

Keywords PAHs;Soil;Pollution;West Qurna- 2 oil field;Southern Iraq

Introduction

Crude and refined petroleum contains PAHs (i.e., petrogenic PAHs). The PAHs are also produced by combustion of fossil fuel (coal and petroleum) and biomass (i.e., pyrogenic PAHs). There are also natural sources of PAHs released to the environment (Zakaria et al., 2002). They can transport over long distances in the atmosphere and deposit in faraway areas,so that they are widely found in the environment (Wang et al., 2015).

The physical, chemical and toxicological properties of PAHs compounds are different and therefore, their evaluation in nature is required. The most grounded cancer-causing agents have been appeared to be benzo(a)anthracene, benzo(a)pyrene and dibenzo(a,h)anthracene. They are multimedia contaminants, reported at elevated levels in several environmental examples i.e. dust, particulate matter, sludge and sewage of different region of the world (Patel et al., 2015). Low molecular weight (LMW) PAHs, containing two or three fused rings, are more water soluble and volatile, along these lines they are more available, than high molecular weight (HMW) PAHs which containing four or more fused rings, hence (LMW) PAHs are more susceptible to different degradation processes. Long term exposure to hydrocarbon compounds can bring about different unsettling in human life in terms of comfort and health (Al-Hejuje et al., 2015).

PAHs may great extent pollute all environmental matrices and raise toxicological, mutagenic and carcinogenic concerns. Inhalation of fine particles, skin contact and ingestion are the main routes of human exposure to PAHs. The determination of PAH concentrations in environmental matrices, for example, soil is important to characterize the levels of environmental contamination and lastly to evaluate the danger of human introduction. Thus, several studies have been conducted in the world on the evaluation of PAH in the soils (Motelay - Massi et al., 2004; Bryselbout et al., 2000; Maliszewska – Kordubach, 1996 and Dan-Badjo et al., 2015).

The main objective of the present study in West Qurna-2 oil field was:

- To investigate the seasonal and spatial distributions of PAH compounds, total organic carbon and grain size.
- To determine the sources and origins of PAH pollution.

Material and Methods

Soil samples were collected seasonally during the period from September 2015 to March 2016 at ten stations in West Qurna-2 oil field at Basrah city (Fig.1). Samples were warped with aluminum foil then transferred to the laboratory for analysis.

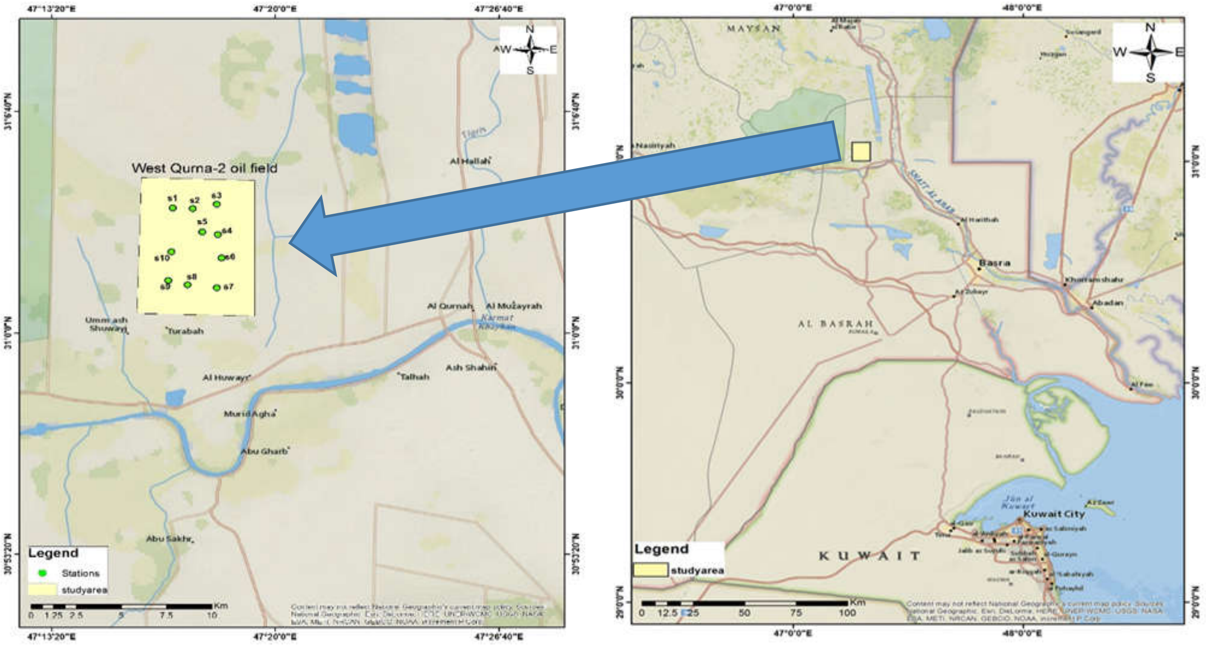

Fig. (1) The study area showing sample locations.

The procedure which described by Grimalt and Olive (1993) and Wang et al., (2011) was used to extracted the hydrocarbons from soil. Twenty five grams of soil were soxhletextracted for 24 hours with 250ml methanol: benzen (1:1). Elemental sulfur was removed from the extracts using activated elemental copper in order to avoid sulfur interferences when using gas chromatography. The extracts were then fractionated into aliphatic and aromatic hydrocarbons by chromatography column. The column was prepared by slurry packing 10g of silica (100-200 mesh), followed by 10g of alumina (100-200 mesh) (silica-gel and alumina were activated at 200° C for 4 hours and then partially deactivated with 5 % water) and finally 1 g of anhydrous sodium sulphate was added to the surface to avoid disturbance of the top layer when pouring the solvent. The extract was then applied to the head of the column and eluted 25 ml of benzene to yield the aromatic hydrocarbons. The aromatic fractions were concentrated on a rotary evaporator, transferred to a vial, and the volume was adjusted to 1 ml exactly using a stream of N_2. An aliquot of 1 µl of extract of aromatic hydrocarbons was subjected to analysis by anallegiant capillary gas chromatography with flam ionization detector (FID). Column (model Agilent 19091J-101HP-5 5%

phenyl Methyl silicone with dimensions for PAHs the temperature of column was held at 80 °C for 2 minute then rate 8 °C /minute to 280°C for 12 min. The individual of PAHs were identified based on the retention time of an authentic mixed standard procured from Supelco, USA.The concentrations and PAHs compounds were calculated based on the standard calibration curve of corresponding standard compounds. 80 % to 92 % are the range of recovery assays for PAHs compounds. Standard deviation for the method was less than 10 % based on replicate analysis. Great care was taken to avoid contamination of the samples throughout the analytical procedure. All solvents were distilled twice before use; glassware was rinsed with distilled water and heated in an oven at 250 °C for 24 hours. However, procedural blanks consisting of all reagents and glassware used during the analysis were periodically determined which had shown no detectable interference. Total Organic Carbon (TOC) content in the soil samples is determined according to Riley and Chester method (1981).

Results and Discussion

Seventeen compounds of PAHs were identified in soil samples in the present study in West Qurna-2 oil field. They were divided into two major groups with respect to their molecular weight. The first included the light (low molecular weight) compounds with two-three fused aromatic rings which consisting of seven compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, and carbazole. The second included the heavy (high molecular weight) compounds with four or more fused aromatic rings consisting of ten compounds: floranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)flouranthene, benzo(k)flouranthene, benzo(a)pyrene, indeno(1,2,3,c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

The total concentrations of total PAHs in soil samples at ten stations were range as following: Station 1 from 0.378 ng/g during summer to 1.595 ng/g during winter, station 2 from 0.807 ng/g during winter to 1.845 ng/g during spring, station 3 from 0.819 ng/g during summer to 2.145 ng/g during winter, station 4 from 0.852 ng/g during summer to 2.792 ng/g during spring, station 5 from 1.286 ng/g during summer to 3.725 ng/g during winter, station 6 from 1.096 ng/g during summer to 3.321 ng/g during winter, station 7 from 1.379 ng/g during summer to 4.892 ng/g during winter, station 8 from 1.517 ng/g during summer to 5.038 ng/g during winter, station 9 from 1.572 ng/g during summer to 7.222ng/g during winter and station 10 from 2.438 ng/g during summer to 9.966 ng/g during winter Tables (1-4). The highest of total PAHs mean concentrations in soil (5.906 ng/g) dry weight was recorded at station 10, while the lowest mean concentrations (1.125 ng/g) was recorded at station 1 (Table 5) (Fig. 2).

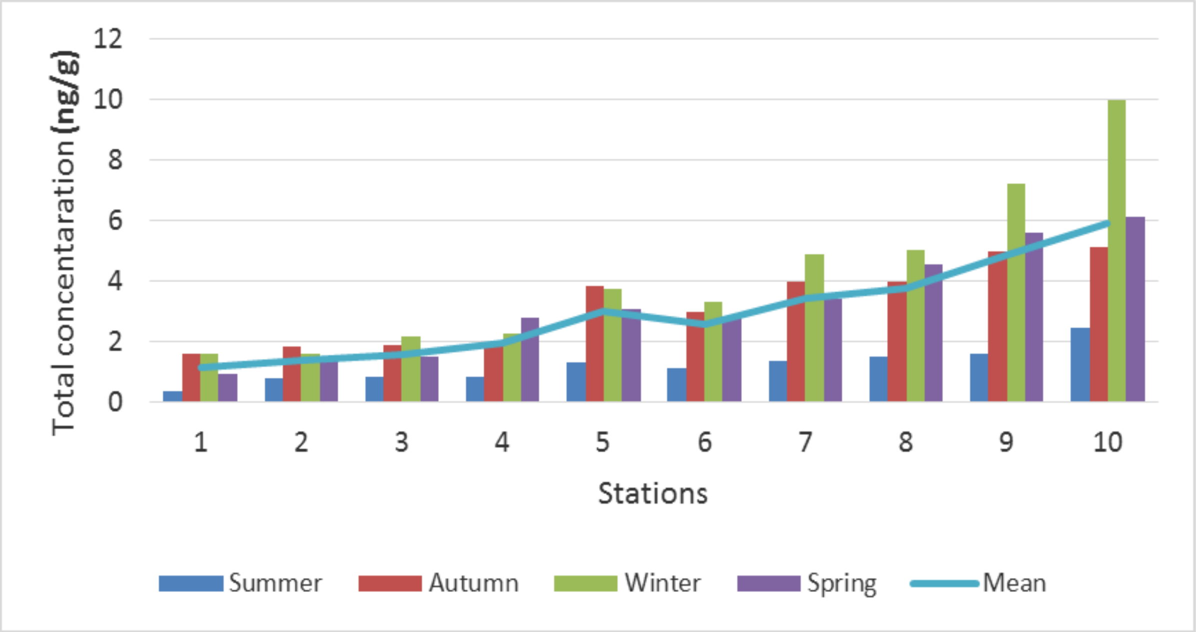

Fig. (2) Seasonal and mean concentration of polycyclic aromatic hydrocarbons at west Qurna- 2 oil field.

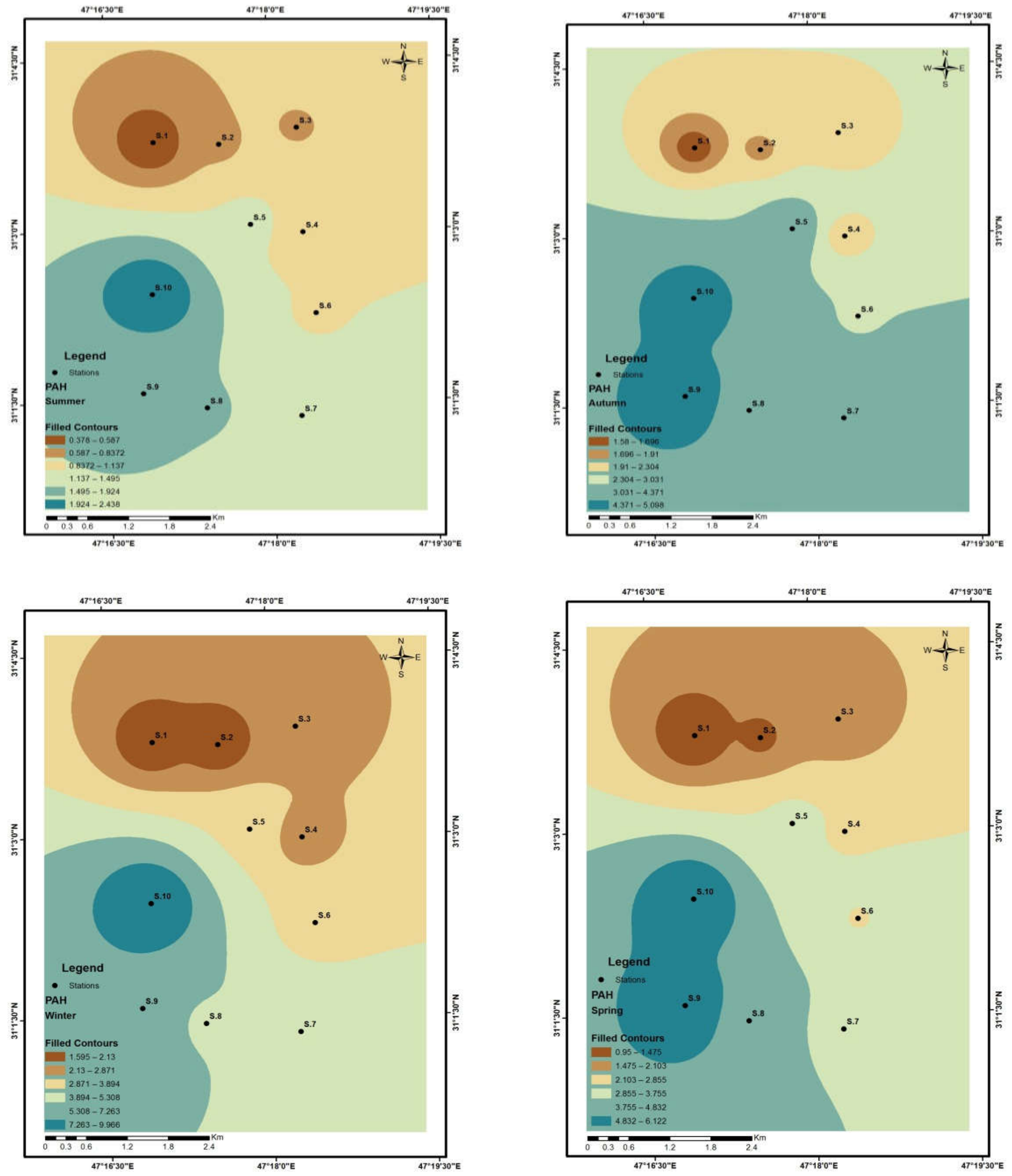

Fig. (3): GIS map showing polycyclic aromatic hydrocarbons distribution in soil at west Qurna- 2 oil field for different seasons.

Seasonal variations of total PAHs were observed during this study. The highest concentrations were observed during winter season while lower concentration observed during summer season (Table 5). Based on our data, the GIS maps were representing the concentrations of total PAHs measured during different seasons (Fig.3).

The predominant light PAHs compounds were acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene and carbazol. While the dominant heavy PAHs compounds were floranthene, pyrene, benzo(a)pyrene**,** benzo(a) anthracene**,** andbenzo(k)flouranthene**.** Benzo(a)anthracene and benzo(a)pyrene are the most effective carcinogens have been found (Patel et al., 2015).

Table (1) Regional concentration of polycyclic aromatic hydrocarbons (ng/g)dry weight in soil of west Qurna -2 oil field during summer season 2015.

PAHs compounds	Station1	2	3	4	5	6	7	8	9	10
Naphthalene	0.014	0.014	0.018	0.013	0.042	0.051	0.012	0.011	0.019	0.019
Acenaphthylene	0.018	0.032	0.045	0.051	0.040	0.064	0.075	0.111	0.090	0.213
Acenaphene	0.028	0.055	0.057	0.020	0.055	0.025	0.042	0.03	0.045	0.127
Fluorene	0.052	0.114	0.087	0.179	0.230	0.088	0.191	0.171	0.202	0.293
Phenanthrene	0.038	0.053	0.051	0.088	0.124	0.066	0.085	0.094	0.106	0.486
Anthracene	0.006	0.086	0.014	0.110	0.057	0.050	0.080	0.014	0.08	0.232
Fluoranthene	0.021	0.04	0.036	0.063	0.083	0.057	0.072	0.076	0.106	0.127
Pyrene	0.064	0.196	0.229	0.043	0.141	0.095	0.256	0.092	0.288	0.480
Benzo(a)anthracene	0.054	0.059	0.063	0.065	0.11	0.049	0.066	0.096	0.094	0.105
Chrysene	0.003	0.005	0.017	0.01	0.037	0.048	0.024	0.066	0.037	0.015
Benzo(b)fluoranthene	0.005	0.014	0.008	0.036	0.013	0.014	0.011	0.015	0.021	0.013
Benzo(k)fluoranthene	0.008	0.010	0.016	0.018	0.028	0.019	0.021	0.032	0.038	0.051
Benzo(a)pyrene	0.022	0.031	0.054	0.049	0.144	0.187	0.116	0.239	0.103	0.087
Carbazole	0.018	0.049	0.059	0.048	0.088	0.112	0.249	0.145	0.216	0.098
Indo(1,2,3-cd)pyrene	0.003	0.007	0.008	0.013	0.025	0.061	0.024	0.075	0.052	0.012
Dibenzoanthracene	0.020	0.021	0.037	0.031	0.043	0.053	0.035	0.080	0.052	0.040
Benzo(g,h,i)perylene	0.004	0.021	0.02	0.015	0.026	0.057	0.02	0.170	0.023	0.040
Total	0.378	0.807	0.819	0.852	1.286	1.096	1.379	1.517	1.572	2.438
Fluoranthen/Pyrene	0.328	0.204	0.157	1.465	0.588	0.6	0.281	0.826	0.368	0.264
Phen/Ant	6.333	0.616	3.642	0.8	2.175	1.32	1.062	6.714	1.325	2.094
LMW/HMW	0.880	0.953	0.602	1.597	0.963	0.576	0.677	0.501	0.701	1.590
Ant/(Ant+Phen)	0.136	0.618	0.215	0.555	0.314	0.431	0.484	0.129	0.430	0.323
BaA/(BaA+Chry)	0.947	0.921	0.787	0.866	0.748	0.505	0.733	0.592	0.717	0.875
InP/(InP+BghiP)	0.428	0.25	0.285	0.464	0.490	0.516	0.545	0.306	0.693	0.230

In all stations along the period of study we observed that HMW-PAHs were more than LMW-PAHs, this may be attributed to the molecular weight. Differences in degradation processes in both low and high molecular weight PAHs was because of wide group of microorganisms including fungi, algae and bacteria. In any case, bacteria play the most important role in completion of mineralization. Lower molecular weight PAHs such as naphthalene and phenanthrene degrade rapidly, but higher molecular weight PAHs such as pyrene, fluoranthene, benzo(a) anthracene and benzo(a)pyrene are more recalcitrant (Bakhtiari et al.,2009; Obayori and Salam, 2010). In expansion to that the low molecular weight PAHs such as naphthalene has the highest vapor pressure of PAHs. Therefore volatilization in environments is probably the most important removal mechanism for these compounds (USEPA, 1982).

The results of regional PAHs at the present study showed a highest concentration of PAHs was in winter at station 10 (9.966 ng/g dry weigh) and the lowest in summer at station 1 (0.378 ng/g to dry weigh), while the higher mean concentration of PAHs in station 10 (5.906 ng/g) and the lowest in station 1(1.125 ng/g) (Table 5).

Variation in the recorded concentrations of the PAHs was observer during the study. They gradually increased starting from station 1 until station 5, and then significantly decreased at station 6 and then increased to station 10. The fluctuation in concentrations of PAHs in stations is due to distance from the flame of the flare which near to the stations 8,9,10 and far to the stations 1,2,3,4,5,6,7.

Table (2) Regional concentration of polycyclic aromatic hydrocarbons (ng/g)dry weight in soil of west Qurna-2 oil field during autumn season 2015.

PAHs compounds	Station1	2	3	4	5	6	7	8	9	10
Naphthalene	0.013	0.021	0.022	0.019	0.021	0.017	0.019	0.049	0.020	0.026
Acenaphthylene	0.043	0.024	0.033	0.036	0.081	0.064	0.056	0.106	0.094	0.129
Acenaphene	0.033	0.013	0.009	0.069	0.042	0.018	0.036	0.033	0.037	0.089
Fluorene	0.112	0.172	0.112	0.085	0.158	0.091	0.304	0.209	0.232	0.202
Phenanthrene	0.101	0.092	0.189	0.156	0.290	0.300	0.253	0.272	0.433	0.475
Anthracene	0.100	0.095	0.085	0.079	0.255	0.242	0.267	0.273	0.196	0.299
Fluoranthene	0.194	0.181	0.160	0.380	0.457	0.307	0.421	0.402	0.545	0.525
Pyrene	0.159	0.240	0.208	0.185	0.475	0.356	0.521	0.480	0.633	0.575
Benzo(a)anthracene	0.121	0.159	0.148	0.139	0.346	0.279	0.408	0.299	0.383	0.503
Chrysene	0.031	0.025	0.042	0.043	0.068	0.042	0.053	0.083	0.106	0.078
Benzo(b)fluoranthene	0.023	0.031	0.030	0.028	0.071	0.048	0.120	0.065	0.093	0.130
Benzo(k)fluoranthene	0.091	0.158	0.100	0.107	0.240	0.292	0.267	0.283	0.346	0.512
Benzo(a)pyrene	0.164	0.184	0.122	0.126	0.331	0.242	0.401	0.331	0.443	0.485
Carbazole	0.236	0.274	0.349	0.218	0.561	0.350	0.417	0.660	0.839	0.640
Indo(1,2,3-cd)pyrene	0.036	0.042	0.053	0.050	0.090	0.064	0.087	0.103	0.062	0.104
dibenzoanthracene	0.086	0.094	0.143	0.149	0.195	0.142	0.192	0.204	0.275	0.180
Benzo(g,h,i)perylene	0.037	0.040	0.097	0.061	0.163	0.115	0.134	0.116	0.227	0.146
Total	1.580	1.845	1.902	1.930	3.844	2.969	3.956	3.968	4.964	5.098
Fluoranthen/Pyrene	1.220	0.754	0.769	2.054	0.962	0.862	0.808	0.837	0.860	0.913
Phen/Ant	1.010	0.968	2.223	1.974	1.137	1.239	0.947	0.996	2.209	1.588
LMW/HMW	0.605	0.479	0.472	0.745	0.513	0.538	0.434	0.512	0.457	0.520
Ant/(Ant+Phen)	0.497	0.508	0.310	0.336	0.467	0.446	0.513	0.500	0.311	0.386
BaA/(BaA+Chry)	0.796	0.864	0.778	0.763	0.835	0.869	0.885	0.782	0.783	0.865
InP/(InP+BghiP)	0.493	0.512	0.353	0.450	0.355	0.357	0.393	0.470	0.214	0.416

There are many sources of PAHs in the environment such as:

The oil industry holds a major potential of hazards for the environment, and may impact it at different levels: air, water, soil, and consequently all living beings on our area. The most widespread and dangerous consequence of oil and gas industry activities is the pollution which associated with all activities throughout all stages of oil and gas production, from exploratory activities to refining. Wastewaters, gas emissions, solid waste and aerosols generated during drilling, production, refining (responsible for the most pollution) and transportation amount to over 800 different chemicals, among which, of course, prevail oil and petroleum products (Farid et al., 2016).

Results of seasonal PAHs concentration in this study showed that the lowest concentrations recorded during summer (1.214 ng/g), while the highest concentrations recorded during winter (4.177ng/g) while spring was (3.216ng/g) and autumn (3.205 ng/g), the seasonal concentration arrange as following: winter >spring>autumn >summer Table (5) and (Fig. 3).

This may be attributed to the climatic condition effect by photo-oxidation, volatilization and high degradation during the hot season. Increasing the evaporation rate and also affect the biodegradation during summer because of the higher temperature (Boyd et al., 2001). Generally the rate of biodegradation decreases with decreasing of temperature and vice versa, so that the highest degradation rates generally occurs in the range 20 to 30Cº in the environments (Bartha and Bossert, 1984). Because of higher energy consumption for heating and increase hydrocarbon compound input to environment with run off during winter season, elevated levels of them during winter may be attributed to their in precipitation which is significantly higher in winter than in summer. In addition during winter, because of lowering in temperature the evaporation rate will decrease, and causes biodegradation lower rate (Al-Khatib, 2008).

The effect of TOC and grain size on the PAHs concentrations in soil was investigated in the present study. The % TOC and grain size of the recent soil are given in Table 6. The % TOC mean values ranged from 0.762% in station 1 to 2.187% in station 10. The variation in % TOC between the stations could be due to different organic matter sources and sedimentary environments. A significant positive correlation between TOC% and total PAHs in the soil were found at this study ($r=0.888$, $P<0.01$). This result was in agreement with (Al–Mahana, 2015), (Al-Saad et al., 2016) and (Farid et al., 2016) the importance of sedimentary organic matter on the PAHs partitioning in sediments had been well documented by Chiou et al. (1998). They found that the high partitioning of PAHs to sedimentary organic matter was mainly due to the significant aromatic fraction of the organic matter. They considered the sedimentary organic matter as a natural “heterogeneous polymer” where PAHs interact more favorably with the aromatic regions. Otherwise there were non-significant correlation between the PAHs in soil and each of the soil texture compounds (sand, silt and clay).

Table (3) Regionalconcentration of polycyclic aromatic hydrocarbons (ng/g)dry weight in soil of west Qurna- 2 oil field during winter season 2015.

PAHs compounds	Station1	2	3	4	5	6	7	8	9	10
Naphthalene	0.013	0.018	0.013	0.035	0.025	0.016	0.011	0.019	0.012	0.026
Acenaphthylene	0.031	0.035	0.024	0.021	0.060	0.058	0.078	0.169	0.120	0.147
Acenaphene	0.007	0.021	0.019	0.014	0.076	0.026	0.040	0.074	0.135	0.157
Fluorene	0.063	0.054	0.050	0.050	0.140	0.144	0.189	0.438	0.263	0.312
Phenanthrene	0.153	0.130	0.228	0.290	0.308	0.360	0.360	0.500	0.548	1.223
Anthracene	0.143	0.170	0.162	0.217	0.173	0.196	0.381	0.524	0.355	1.082
Fluoranthene	0.114	0.132	0.242	0.184	0.322	0.338	0.646	0.581	0.769	1.044
Pyrene	0.417	0.293	0.161	0.193	0.517	0.216	0.901	0.523	0.801	1.486
Benzo(a)anthracene	0.086	0.052	0.125	0.132	0.138	0.197	0.368	0.277	0.434	0.500
Chrysene	0.031	0.025	0.044	0.056	0.107	0.088	0.095	0.158	0.234	0.285
Benzo(b)fluoranthene	0.019	0.015	0.050	0.114	0.041	0.096	0.128	0.094	0.214	0.160
Benzo(k)fluoranthene	0.074	0.113	0.177	0.035	0.263	0.205	0.285	0.214	0.546	0.532
Benzo(a)pyrene	0.053	0.112	0.290	0.163	0.197	0.158	0.557	0.405	0.525	0.655
Carbazole	0.219	0.196	0.318	0.316	0.682	0.648	0.444	0.624	1.640	1.498
Indo(1,2,3-cd)pyrene	0.021	0.038	0.053	0.112	0.121	0.050	0.067	0.119	0.205	0.197
Dibenzoanthracene	0.069	0.147	0.123	0.211	0.425	0.173	0.149	0.130	0.223	0.440
Benzo(g,h,i)perylene	0.072	0.055	0.058	0.111	0.120	0.343	0.183	0.181	0.191	0.213
Total	1.595	1.613	2.145	2.262	3.725	3.321	4.892	5.038	7.222	9.966
Fluoranthen/Pyrene	0.275	0.450	1.502	0.951	0.623	1.561	0.717	1.111	0.960	0.702
Phen/Ant	1.063	0.763	1.405	1.334	1.782	1.839	0.945	0.954	1.542	1.129
LMW/HMW	0.494	0.211	0.528	0.562	0.423	0.524	0.537	0.846	0.439	0.669
Ant/(Ant+Phen)	0.484	0.567	0.415	0.428	0.359	0.352	0.513	0.511	0.393	0.469
BaA/(BaA+Chry)	0.734	0.678	0.736	0.701	0.563	0.689	0.793	0.636	0.650	0.636
InP/(InP+BghiP)	0.230	0.406	0.480	0.503	0.502	0.129	0.267	0.396	0.517	0.481

Table (4) Regional concentration of polycyclic aromatic hydrocarbons (ng/g)dry weight in soil of west Qurna-2 oil field during spring season 2016.

PAHs compounds	Station1	2	3	4	5	6	7	8	9	10
Naphthalene	0.054	0.035	0.018	0.070	0.021	0.049	0.013	0.036	0.040	0.046
Acenaphthylene	0.044	0.049	0.042	0.126	0.147	0.117	0.172	0.158	0.250	0.190
Acenaphene	0.023	0.033	0.037	0.072	0.115	0.069	0.081	0.119	0.131	0.087
Fluorene	0.087	0.157	0.094	0.216	0.239	0.250	0.270	0.391	0.299	0.304
Phenanthrene	0.146	0.152	0.185	0.270	0.270	0.303	0.287	0.414	0.492	0.564
Anthracene	0.044	0.094	0.030	0.249	0.523	0.121	0.207	0.404	0.075	0.250
Fluoranthene	0.063	0.094	0.068	0.148	0.189	0.187	0.252	0.292	0.165	0.532
Pyrene	0.047	0.098	0.080	0.490	0.237	0.217	0.630	0.420	0.247	0.455
Benzo(a)anthracene	0.090	0.084	0.039	0.194	0.332	0.132	0.207	0.377	0.147	1.025
Chrysene	0.011	0.031	0.032	0.051	0.056	0.070	0.077	0.085	0.211	0.131
Benzo(b)fluoranthene	0.014	0.021	0.016	0.039	0.056	0.045	0.086	0.073	0.036	0.131
Benzo(k)fluoranthene	0.116	0.058	0.188	0.166	0.135	0.151	0.070	0.277	0.162	0.525
Benzo(a)pyrene	0.050	0.121	0.082	0.235	0.269	0.286	0.352	0.524	0.250	0.471
Carbazole	0.089	0.132	0.172	0.332	0.271	0.428	0.342	0.622	0.986	0.879
Indo(1,2,3-cd)pyrene	0.014	0.036	0.049	0.039	0.060	0.083	0.076	0.090	0.250	0.123
Dibenzoanthracene	0.043	0.078	0.164	0.076	0.112	0.182	0.146	0.186	1.087	0.264
Benzo(g,h,i)perylene	0.015	0.075	0.205	0.019	0.043	0.140	0.141	0.079	0.761	0.145
Total	0.950	1.348	1.501	2.792	3.075	2.830	3.409	4.547	5.589	6.122
Fluoranthen/pyrene	1.340	0.959	0.850	0.302	0.797	0.861	0.400	0.695	0.668	1.169
Phen/Ant	3.318	1.617	6.166	1.084	0.516	2.504	1.386	1.024	6.560	2.256
LMW/HMW	0.942	0.836	0.049	0.701	0.957	0.631	0.602	0.663	0.350	0.475
Ant/(Ant+Phen)	0.231	0.231	0.139	0.479	0.659	0.285	0.419	0.493	0.132	0.307
BaA/(BaA+Chry)	0.891	0.730	0.549	0.791	0.855	0.653	0.728	0.816	0.410	0.886
InP/(InP+BghiP)	0.482	0.324	0.192	0.672	0.582	0.372	0.350	0.532	0.247	0.458

LMW/HMW ratio ranged from (0.049) at station 3 in spring to (1.597) at station 4 in summer. PAHs compounds according to the LMW/HMW ratio, the main source of PAHs in soil of West Qurna-2 oil field was pyrogenic origin, phenanthrene/anthracene ratio was ranged from (0.616) at station 2 in Summer to (6.714) at station 8 in summer. According to the ratio values, the source of PAHs in soil was pyrogenic.

The flouranthene/pyrene ratio ranged from (0.157) at station 3 in summer to (2.054) at station 4 in autumn. According to the ratio values, the source of PAHs in soil was pyrogenic (combustion sources) and petrogenic (petroleum contaminations).

BaA/(BaA+Chry) Ratio was ranged from (0.410) at station 9 in spring to (0.947) at station 1 in summer. According to the ratio values, the source of PAHs in soil was pyrogenic.

InP/(InP+BghiP) Ratio was ranged from (0.129) at station 6 in winter to (0.693) at station 9 in summer. According to the ratio values, the source of PAHs in soil was petrogenic or pyrogenic.

Ant/(Ant+Phen) ranged from (0.129) at station 8 in Summer to (0.659) at station 6 in spring. According to the ratio values, the source of PAHs in soil was pyrolytic.

Our data indicate that the level of PAHs which observed in west Qurna -2 oil field lie within the range of values reported for comparable areas Table (7).

Table (5) Seasonalvariationof totalpolycyclic aromatic hydrocarbons (ng/g) with mean in west Qurna 2 oil field.

Stations	Summer	Autumn	Winter	Spring	R. Mean	±SD
1	0.378	1.58	1.595	0.95	1.125	0.582
2	0.807	1.845	1.613	1.348	1.403	0.446
3	0.819	1.902	2.145	1.501	1.591	0.579
4	0.852	1.93	2.262	2.792	1.959	0.818
5	1.286	3.844	3.725	3.075	2.982	1.180
6	1.096	2.969	3.321	2.83	2.554	0.993
7	1.379	3.956	4.892	3.409	3.409	1.485
8	1.517	3.968	5.038	4.547	3.767	1.562
9	1.572	4.964	7.222	5.589	4.836	2.375
10	2.438	5.098	9.966	6.122	5.906	3.120
S. Mean	١.٢١٤	٣.٢٠٥	٤.١٧٧	٣.٢١٦	-	-

R.Mean= regional mean, S. Mean= seasonal mean.

Table (6) Seasonal variation of TOC% andgrain size in west Qurna-2 oil field.

Station	TOC%				Grain size			
	Summer	Autumn	Winter	Spring	Clay%	Silt%	Sand%	Clay%
1	0.256	0.558	1.116	1.118	2	70	28	2
2	0.358	0.651	1.162	1.162	1	41	58	1
3	0.461	1.023	1.441	1.213	3	68	29	3
4	0.666	1.038	1.581	1.415	1	47	52	1
5	0.923	1.829	1.813	1.668	1	76	23	1
6	0.82	1.162	1.674	1.649	2	32	66	2
7	0.974	1.953	1.891	1.668	1	42	57	1
8	1.025	2.046	2.000	1.800	1	56	43	1
9	1.179	2.093	2.418	1.876	1	39	60	1
10	1.282	2.511	2.511	2.445	2	73	25	2

Table (7): Comparison between the levels of PAHs (ng/g dry weight) in soil for the present study with the previously studies.

Studied Areas	PAHs (ng/g)	References
Shatt Al-Arab River &NW Arabian Gulf	8.42- 70.56	Al-Saad (1995)
Al-Howaiza Marsh	0.1 – 145.8	Al-Khatib (2008)
Iraqi Coast Region	12.15-47.38	Al-Khion (2012)
Shatt Al-Arab River	4.318 – 28.48	Al-Hejuje(2014)
Shatt Al-Arab River	60.362-1.630	Al–Mahana (2015)
West Qurna-2 Oil field	0.378 -9.966	The present work

Conclusion

The PAHs compounds can be divided into two major groups (Low Molecular Weight (LMW) that consist of 2-3 fused rings, and High Molecular Weight(HMW) that consist of 4 and more fused rings. From the LMW/HMW, phenanthrene/anthracene and benzo(a)anthracene/benzo(a)anthracene+ chrysene ratio, the source of PAHs compounds are mainly pyrogenic, while Flouranthene/Pyrene Ratio and InP/(InP+BghiP) Ratio is pyrogenic+ petrogenic origin and petrogenic or pyrogenic and Ant/(Ant+ Phen) Ratio was pyrolytic. The higher regional mean concentrations of PAHs were recorded in station 10, while the lower in Station 1. The higher seasonal mean concentrations of PAHs are recorded during winter season, while the lower during summer season.

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