Original Research Article

Estimation of environmental chemical pollution of Al-Baiji Oil Refinery in Iraq

ABSTRACT

All kinds of industries like oil plants, petrochemicals and chemical industries are causing tremendous chemical pollution of environment components like air, water and soil. The first target of chemical pollution is the environment of the refinery itself. It was seen that the protection and control measures of chemical pollution locally followed for oil refinery environment and its community were very limited.This worse situation might lead health hazards to workers in oil refinery and consequently to its vicinity. This study was conducted to assess the degree of chemical pollution and impact caused by Al-Baiji Oil Refinery of Iraq on its own environment. Six heavy metals concentrations were estimated in selected samples of soil and water collected from different sites in oil refinery by using atomic absorption spectrophotometery . These metals were cadmium, copper, nickel, lead, vanadium and zinc. Estimation of pollutant gases utilized a portable digital device. Results showed that some of the heavy metals tested (Cu and Zn) were at acceptable levels whereas the other four heavy metals(cadimium,nickel,lead and vanadium) revealed higher values than maximum allowable limits. Determination of hydrogen sulphide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO) and oxygen (O_2) gases were also done. Acceptable concentrations of H_2S (4.16) ppm and CO (29.5) ppm were recorded, while those of NO_2 (0.108) ppm and O_2 (20.6%) ppm were not acceptable. Inhalation of metal particles might be more dangerous than through gastrointestinal tract(GIT) or dermal routes. Concentration of gaseous pollutants was almost close to the acceptable concentrations, with exception of nitrogen dioxide which was noted to be more than the acceptable limits.

Key words:Soil,water,air,chemical pollution, oil refinery,Iraq

INTRODUCTION

All kinds of industries like oil plants, petrochemicals and chemical industries are causing tremendous pollution to the nature and its environments like air, water and soil(Ezejiofor et al.2013).Iraq is one of oil producing countries which always under risk of chemical pollution due to oil industries and/or exportation(Saadoun et al.2008). The first target of chemical pollution is the environment of the refinery itself (Chen,1998:WHO, 2002a). At the same time outcome of the burning process like ashes, carbon monoxide (CO), carbon dioxide (CO_2), hydrogen sulphide (H_2S), methane (CH_4) and other poisonous compounds of hydrocarbons are spreading all over the pick up region (3- 4 Km radius) from the burning point (Laden *et al*., 2006). This is causing another harmful pollution to the nature and residents as well. The target of all chemical pollutants is air, and water later. These pollutants reach the soil in two ways: dry and wet deposition (Postel, 1984). Since particles are also present in polluted emissions, rain can participate in landing them soon. In addition, droplets can also act as attractants for bacteria and other pathogenic agents. In this situation, threats of health will be duplicated from both chemical and biological sources (Barhad, 1983). Long term exposure to critical concentrations of air born pollutants can lead to promote new infections or exacerbate old respiratory tract infections and other diseases (Bates *et al*., 1990; Norris *et al*., 1999). Steadily existing of particles in air inhaled by workers make wide changes in equilibration of biochemical reactions in human body. The most sensitive portion is the respiratory system due to the direct exposure to the toxicants. Therefore, human body begins to response negatively to these factors. Many studies showed that people exposed to industrial pollution have to develop symptoms of respiratory tract infection (Chiodo and Rolfe, 2002). There are many respiratory infections such as tonsillitis, bronchitis, pharyngitis and chest infections(Melia et al.1982) occur as a result of negligence and failing to comply with the legislations and laws of work (Skrtic, 2006).

Materials and Methods

Description of the Refinery.

This study was carried out in the North Refineries Company (NRC), which is one of the most important projects in the country. It is lies 5 Km in North of Baiji town which is about 245 km to the North of Baghdad. This important factory was established in 1980. It is the major oil company designed for local consumption of petroleum products and exportation of the surplus outside the country.Total 8000 workers are employed in the refinery who were actively engaged in six main sections.These sections are subdivided into major subsections. The section of production is one of those where the worker exposed to the direct and indirect risks of chemical pollution.

Samples of Soil and Water.

Five samples of soil were collected from five different sites of the refinery known as chemically polluted areas according to the prevailing wind and the activity of these sites (Nyomora *et al*., 1997).

The steps applied for sampling are as follow:

Step 1: Holes with an area of 25 × 25cm were dugged.

Step 2 : Soil samples were taken from depth of 5- 15cm.

Step 3 : The soil samples were collected in polyethylene containers previously treated and rinsed with distilled water and Mueller solution of hydrochloric acid(Hanns,1984).

Step 4 : The samples were taken from hole sizes of 1.7mm and homogenized . These samples were labeled as S_1, S_2, S_3, S_4, and S_5 being prepared for analysis.Three different sample from the same site were taken to increase the degree of metal recovery;these

were thoroughly mixed to be homogenized and a specimen of them was taken for further chemical invistigations (Suciu *et al*., 2006). Samples of water were also taken directly from drinking water , water of irrigation, fire fighting water system, and industrial water from cooling unit and labeled as W_1, W_2, W_3, and W_4, respectively. Samples were put in polyethylene containers (Yeh *et al*., 1976).

Estimation of Pollutant Gases.

Rates of pollutant gases were utilizing a portable digital device type: iTX Multi-Gas monitor (P/N 1810-4307,USA) . These gases were carbon monoxide (CO), hydrogen sulphide (H2S), nitrogen dioxide (NO2), and oxygen (O2). The device can - optionally- take samples of gases from the space in cases of emergency by a plastic tube through the pump and read the concentrations (Manual of directions of manufacturers, Industrial Scientific Corporation, 2003).

Statistical Analysis

Statistical analysis was applied by using the Chi square and t- test (the means of treatments are compared by Duncan's Multiple Range test) under the level of significance ($p \leq 0.05$).

Results and Discussion

Estimation of Heavy Metals in Soil.

Cadmium in soil which was taken from different sites ranged from 0.4 to 0.6 ppm. This result was consistent with the findings of Aiyesanmi (2005) who concluded that the rate of cadmium concentration was higher in polluted soil (0.76 ppm) compared to 0.02 ppm from unpolluted soil. The values of lead estimated were almost similar i.e.equal in the five samples of soil tested which showed low concentrations (< 0.1 ppm), while the expected values in such contaminated areas are up to 300 ppm

(USEPA, 2007). This finding might be due to the depth (5-15 cm) the samples of soil. The other ranges of concentrations concluded were 2.37- 5.0, 7.53 - 12.4, 85 - 130 and 6.43 - 17 ppm for copper, nickel, vanadium and zinc respectively (Table 1). These results were almost similar to those found by Hassen *et al.* (1998). Normal values of vanadium were found in all five samples tested. Statistical analysis shows no significant differences (using Anova test *P* more than 0.05) among the five soil samples for all the six heavy metals tested.

Table 1: Concentrations of Heavy Metals Estimated in Samples of Soil in the Refinery.

Samples site	Values of heavy metals (ppm)					
	Cd	Cu	Ni	Pb	V	Zn
S_1	0.5	5	7.53	< 0.1	100	17
S_2	0.4	4.2	11.8	< 0.1	95	16.8
S_3	0.6	3.44	10.1	< 0.1	90	9.69

S_4	0.5	2.37	12.2	< 0.1	94	6.43
S_5	0.5	2.6	12.4	< 0.1	85	7.95
MAL*	**3**	**30**	**80**	**100**	**100**	**200**

Cd, cadmium; Cu, copper; Ni, nickel; Pb, lead; V, vanadium; Zn, zinc; S_1, near Xylene unit; S_2, near Storages; S_3, near Fuel oil system; S_4, near Vacuum gas oil; S_5, near Kerosene unit; * Maximum Allowable Levels demonstrated by USEPA (2007).

Estimation of Heavy Metals in Water

The four samples of water collected showed equal but not acceptable values for cadmium, nickel, lead and vanadium according to the WHO (2003). The slight increase of copper value recorded in water of irrigation (W_2) and water of cooling unit (W_4) might be due to the fact that these two sources of water were from open pools, thus, they could be directly exposed to the heavy metals (Hamoda and Al-Haddad, 1987). The lead estimation in the four samples showed equal values (< 0.1) ppm (Table 2). This value might be above the acceptable limits of WHO (2003) which recommends not to exceed 0.01 ppm. This result might be due to the prevailing characteristics of the ground (Mighall *et al*., 2002). Merian (1991) suggested that the sources of lead are mainly from weathering of minerals and soils. This finding was also agreed with the current study which revealed the same value (< 0.1 ppm) in water samples. Generally, the four samples did not show significant differences (using Anova test *P* value more than 0.05).

Table 2: Concentrations of Heavy Metals Estimated in Samples of Water in the Refinery

Samples site	Heavy metals concentrations(ppm)					
	Cd	Cu	Ni	Pb	V	Zn
W_1	< 0.01	0.07	< 0.1	< 0.1	<0.01	< 0.01
W_2	<0.01	0.1	< 0.1	< 0.1	<0.01	<0.01
W_3	< 0.01	0.08	< 0.1	< 0.1	<0.01	<0.01
W_4	<0.01	0.1	< 0.1	< 0.1	<0.01	<0.01
MAL*	**0.003**	**2**	**0.07**	**0.01**	**0.001**	**10**

Cd, cadmium; Cu, copper; Ni, nickel; Pb, lead; V, vanadium; Zn, zinc; W_1, Drinking water; W_2, Water of irrigation; W_3, Fire fighting water system; W_4, Industrial water from cooling unit water; *Maximum Allowable Levels demonstrated by WHO (2003).

Estimation of Gases in Refinery

H_2S, NO_2, CO and O_2 gases were monthly measured for one year, and they revealed different values (Table 3). H_2S readings in the three sites: Salahuddin 1, Salahuddin 2 and North refinery (R_1, R_2 and R_3, respectively) ranged from 0.0 to 27 ppm, and the mean average is 4.16 ppm, while the average values of these three sites were 7.08, 3.41 and 2.00 ppm, respectively. The present results of the study showed that highest mean of H_2S was in warmer months,*e.g.* Oct. 2008 (9.00 ppm) and Apr. 2009 (8.00 ppm) and the lowest mean was found in coldest months,*e.g.* Jan. 2009 (0.00 ppm) as shown in Table 3.The mean average of NO_2 was 0.106 ppm while its values in the three sites were 0.10, 0.09 and 0.13 ppm, respectively. The highest means of NO_2 were 0.300, 0.166 and 0.200 ppm, while the lowest values of mean did not affect by environmenta temperature,*i.e.* Dec. 2008, Feb, Mar., Apr., May and Jan. 2009. The average of NO_2 during the year of the study was more than acceptable concentrations according to the USEPA (1996), which is determined as 0.053 ppm. The continuous emission of pollutant gases resulted pathophysiology of respiratory system and produced impaired pulmonary function for workers (Dales *et al*., 1989; Bauer *et al*., 1986).

The mean average of CO was 29.5 ppm and the three sites revealed 32.08, 24.3 and 32.16 ppm, respectively. The highest mean of CO was recorded in Oct. 2008 and the lowest mean value was seen in May 2009. The three sites revealed very close values of O_2 with an equal averages of 20.6 %. Statistical analysis showed significant differences (using Anova test at $p \leq 0.05$) for H_2S, NO_2 and CO.

The means of O_2 percentages were almost similar values. The highest value (20.9%) was recorded in coldest months of 2009 and the lowest value(20.2%) was estimated in warmest months of 2009. In general, H_2S, CO and O_2 showed

acceptable values according to USEPA (1996). Statistical analysis showed high significant differences (using Anova test at $p \leq 0.01$) concerning O_2.It was concluded from the present study that chemical pollutants studied were highly correlated and interacted (Melia *et al*., 1982).

Table 3: Concentration of Gases Estimated at the Three Sites of the Refinery.

MONTHS	GASES / SITES	H_2S (ppm)	MEAN	NO_2 (ppm)	MEAN	CO (ppm)	MEAN	O_2 (%)	MEAN
October 2008	**R 1**	27	9a	0.3	0.3a	12	44.3a	20.4	20.5c
	R 2	0		0.2		5		20.5	
	R 3	0		0.4		116		20.7	
November 2008	**R 1**	6	2.6ce	0	0.06c	60	33c	20.9	20.8ab
	R 2	2		0		35		20.7	
	R 3	0		0.2		4		21	
December 2008	**R 1**	3	2.6ce	0	0.03d	40	28.3d	20.6	20.5c
	R 2	1		0		10		20.3	
	R 3	4		0.1		35		20.7	
January 2009	**R 1**	0	0e	0	0.1bc	50	35.3bc	20.9	20.9a
	R 2	0		0.2		32		20.9	

	R 3	0		0.1		24		20.9	
February 2009	**R 1**	14	6.6ab	0	0.03d	42	26.3de	20.7	20.7b
	R 2	6		0		22		20.8	
	R 3	0		0.1		15		20.7	
March 2009	**R 1**	0	1de	0	0d	11	21.3ef	20.8	20.8ab
	R 2	3		0		27		20.9	
	R 3	0		0		26		20.7	
April 2009	**R 1**	0	8a	0.2	0.1bcd	33	26.6de	21	20.9a
	R 2	16		0		22		20.9	
	R 3	8		0.1		25		20.9	
May 2009	**R 1**	6	2.6cde	0.1	0.1bcd	43	20f	20.5	20.5c
	R 2	0		0.2		11		20.4	
	R 3	2		0		6		20.7	
June 2009	**R 1**	0	3cd	0.1	0.06cd	16	22.6ef	20.3	20.7d
	R 2	4		0		19		20.1	
	R 3	5		0.1		33		20.4	
July 2009	**R 1**	12	5bc	0.2	0.16ab	42	33c	20.8	20.5c
	R 2	3		0		24		20.7	
	R 3	0		0.3		33		20.1	
August 2009	**R 1**	6	5bc	0	0.2a	24	39ab	20.9	20.7b
	R 2	4		0.4		56		20.5	
	R 3	5		0.2		37		20.7	
September 2009	**R 1**	11	4.3bc	0.3	0.13bc	12	24.3def	20.1	20.4c
	R 2	2		0.1		29		20.6	
	R 3	0		0		32		20.6	
Mean average of the twelve months of the study for R1, R2, and R3		**4.14**		**0.106**		**29.5**		**20.6**	
Mean of concentration in R1		**7.08**		**0.10**		**32.08**		**20.6**	
Mean of concentration in R2		**3.41**		**0.09**		**24.3**		**20.6**	

Mean of concentration in R3	**2.00**	**0.13**	**32.16**	**20.6**
Global limitations *	**10**	**0.053**	**35**	**21**

* Global limitations were demonstrated by (USEPA, 1996);Values in each column followed by similar letters are not significantly different.

Conclusion

It was concluded that concentrations of heavy metals in soil and water of oil refinery were higher than the maximum allowable levels recommended by WHO.Gases of Al-Baiji oil refinery of Iraq especially NO_2 were elevated too. These high levels of chemical pollutants suggest a lack of efficient control measures in the refinery. Consequently, this situation might lead to pathophysiological changes of human body systems particularly the respiratory tract of refinery workers and the vicinity community.

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