PRELIMINARY ASSEMMENT OF INDUSTRIAL WASTEWATER DATABASE IN KUWAIT

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ABSTRACT

A research study was carried out to collect data on the quality and quantity of petroleum and non-petroleum industrial wastewater from different sources in Kuwait over a period of one year as well as developing a database of such characteristics and attributes using geographic information system (GIS) technique. A total of 75 field surveys were conducted during the course of the reporting period. During the field visits, a specially designed field surveys were submitted to the owners of industrial facilities in three industrial areas in Kuwait, namely, Sabhan, Kuwait City, and Shuaiba Industrial Areas. The responses of these industries were collected and analyzed. The obtained results indicate that the activities of these industries can be compartmentalized under 20 industrial categories including 11 and 37 petroleum and non-petroleum industries, respectively. Furthermore, the obtained field data suggest that only a few industries use on-site wastewater treatment systems. It was evident from analysis of results that the pH and DO are much lower for Petroleum vs Non Petroleum indicating acidic conditions and slightly anaerobic conditions of the Petroleum industries so far in the sampling campaign. The acidic conditions is also supported by the higher free chlorine in the Petroleum industries. However, on the TSS, BOD, COD, TOC and many other pollutants are higher in the Non Petroleum industries. Although this result may seem paradoxical, however, it indicates better process control.

Keywords: Sample collection, categorization, field survey, database and treatment.

1 INTRODUCTION

Kuwait is one of the water-stressed countries of the world. The main source of water supply for municipal uses is the costly desalinated seawater. Groundwater supply in the country is depleting in an alarming rate. One of the main users of groundwater is the petroleum industry as it uses a major portion of the water supply for petroleum extraction and associated industries. Living with the reality of the high cost of water production and scarcity of water resources other than the sea, Kuwait is in dire need of an integrated water resources management scheme that includes aspects of water conservation and reuse wherever possible. The foundation block of such a management scheme is a sound database of all potential sources of water supply, supply locations, use, after-use discharge, recycle potential, reuse, environmental impacts, and sustainability of the national resources and developmental systems. One of the major sectors involved in such a scheme is industrial (petroleum and non-petroleum) water use and wastewater generation, including areas of after-use discharges, wastewater quality at origins and discharge points, locations of discharge and/or reuse, and recycle potential. A basic and comprehensive database utilizing ArcGIS in this sector is presently lacking in the country. A comprehensive, centralized, well formatted and compiled data system on the type and quality of industrial wastewater produced with specifics of location, quality, provision of treatment and discharge and/or reuse in the country is presently missing. Accordingly, this study was initiated to collect data on the quality and quantity of petroleum and non-petroleum industrial wastewater from different sources in Kuwait over a period of one year. Additionally, the study aims at developing a database on the above-mentioned attributes using geographic information system (GIS) technique. The study is a continuation of a previous project (Shahalam et al., 2008) that aimed at collecting data on the quality of wastewater streams from various sources in Kuwait and developing a state-wide

database on the quality of wastewater generated at selected industrial sources in an attempt to develop a baseline information source of wastewater quality for the country.

This paper reports on the progress in the project during the initial phases. During the subsequent phases of the project, the quantities and quality of the wastewater in these industries will be recorded using flowmeters and industrial wastewater samples to be collected over a period of one year. The collected wastewater samples will be analyzed at KISR laboratories to determine their inorganic and organic contents. The obtained laboratory results will be compared against local and international wastewater standards in an attempt to come up with recommendations on future national programs designed to enhance industrial wastewater treatment and effluent quantity and quality and to suggest the required treatment in lieu of an integrated water resources management scheme for the State of Kuwait.

2 METHODOLOGY

2.1 Mobilization and Survey of Industries

As part of this task, the procurement of instruments, associated training, and experimental supplies was completed. The instruments were used to carry out sample analysis in accordance with APHA (2017) and following the procedure of the ISO certified water research center (WRC) laboratories. Also, as part of this task, a field survey was conducted during which a specially designed questionnaire was distributed among the targeted industries. It is worth mentioning that the industries in Kuwait are mainly distributed in three areas, namely Kuwait City, Sabhan, and Shuaiba industrial areas (Fig. 1). Shuaiba industrial area represents factories of petroleum wastewater origin, while the other sites (Kuwait City, Sabhan) represent factories of non-petroleum wastewater origin. Three teams from Kuwait Institute for Scientific Research (KISR) were assigned for each industrial site to complete the intended field surveys. A summary of the English field survey is shown in Table 1.

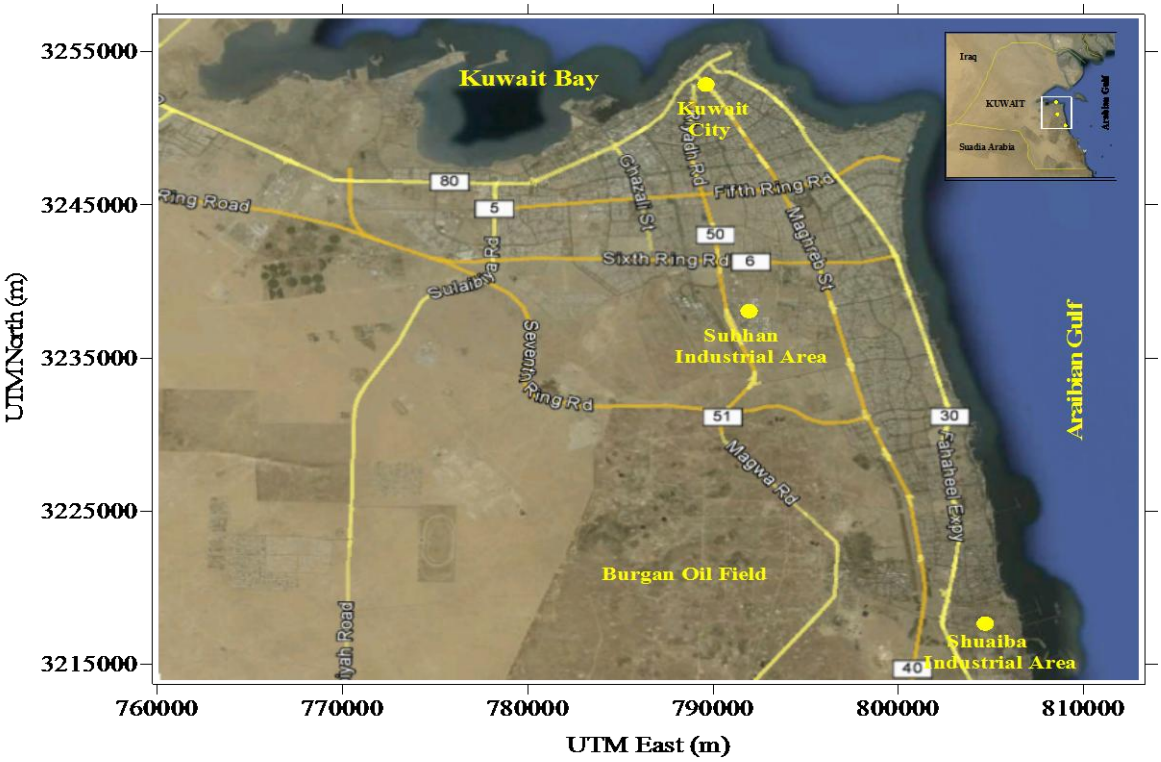

Figure1. Location map of the study area.

Table 1. English Field Survey for Industries

Survey Date:	**Survey Time:**	**Surveyor(s):**

No.	**Survey Questions**	**Circle Answer or Fill Blanks**
1	Letter from Public Authority for Industry (PAI) provided?	Yes / No
2	Letter to factory representatives/owner provided? (include name of representative)	Yes / No Rep.:
3	What is the name of factory?	
4	Where is the location of factory area?	Sabhan / Kuwait City / Shuaiba
5	Factory coordinates;	
6	Industrial purposes of water use (if other please specify):	Sanitary / Irrigation / Industrial
7	Factory activities/productions?	
8	Factory category?	
9	Number of production lines active?	
10	Sampling point(s) coordinates;	
11	Has the surveyor examined the sampling point?	Yes / No
12	Is there a need for any personal protective equipment (PPE)?	Yes / No
13	Flow meter available?	Yes / No
14	If a flow meter is not available, will the factory allow installation?	Yes / No
15	Depth of sampling point?	Meters
16	Sampling method?	Bailer P umping
17	Is there sufficient space to collect samples at the location?	Yes / No
18	Is there sufficient space to perform fluid measurements?	Yes / No
19	Can the factory accommodate 20 mo. of sampling?	Yes / No
20	Does the factory produce sufficient industrial wastewater flow for sampling?	Yes / No
21	Does the factory perform pretreatment on wastewater before discharge?	Yes / No
22	Is there any data within the past 5 years on the quality of discharge?	Yes / No
23	Is there any data within the past 5 years on the quantity of discharge?	Yes / No
24	Is the industrial wastewater discharge mixed with domestic wastewater?	Yes / No
25	Methods of wastewater discharge?	Tankers / Sewage Network
26	How many tankers/week are sent to Wafra Industrial Wastewater Plant?	Pick up time: /week
27	Does the factory participate in industrial wastewater reuse? (if other please specify)	Reuse / Recycle / Recovery
28	Pretreatment of wastewater streams (if other please specify):	Yes / No
29	Does the factory follow KEPA - Law 42?	Yes / No

30	Does the factory receive visits from EPA Staff?	Yes / No Avg. no.:
31	Total electricity consumption in factory:	
32	Total freshwater consumption in factory:	
33	Number of wastewater streams	
34	Raw materials used	
35	Mode of manufacturing	Batch / Continuous
36	Are there flow diagrams showing the points of addition of water and chemicals?	Yes / No
37	Are there any adverse environmental impacts of industrial wastewater?	

2.2 Industrial Wastewater Sampling and Laboratory Analysis

Based on the field surveys of the targeted industries, the total number of factories and sites to be visited for wastewater sampling and associated measurements was determined (Tables 2 and 3). The wastewater sampling plan was prepared along with the distribution of the collected samples to the concerned laboratories of KISR's Water Research Center (WRC) and the Environment and Life Sciences Research Center (ELSRC) in Shuwaikh and Sulaibiya premises. In the data analysis section, the laboratory results of the wastewater samples was compared with local standards (KEPA, 2017), and international wastewater standards FAO (1992), WHO (2006) and USEPA (2011).

Table 2. Code of Non-Petroleum Industries for Industrial Wastewater Database

Sr. No.	Industry Category	Sampling Code
1	Rubber Products1	NP01(KC/SH/SB)01
2	Plastic Products1	NP02(KC/SH/SB)01
2	Plastic Products2	NP02(KC/SH/SB)02
2	Plastic Products3	NP02(KC/SH/SB)03
3	Glass and Glass Products1	NP03(KC/SH/SB)01
3	Glass and Glass Products2	NP03(KC/SH/SB)02
3	Glass and Glass Products3	NP03(KC/SH/SB)03
4	Cement, Lime, and Plaster1	NP04(KC/SH/SB)01
5	Nonmetallic Mineral Products1	NP05(KC/SH/SB)01
5	Nonmetallic Mineral Products2	NP05(KC/SH/SB)02
5	Nonmetallic Mineral Products3	NP05(KC/SH/SB)03
5	Nonmetallic Mineral Products4	NP05(KC/SH/SB)04
5	Nonmetallic Mineral Products5	NP05(KC/SH/SB)05
5	Nonmetallic Mineral Products6	NP05(KC/SH/SB)06
5	Nonmetallic Mineral Products7	NP05(KC/SH/SB)07
5	Nonmetallic Mineral Products8	NP05(KC/SH/SB)08
5	Nonmetallic Mineral Products9	NP05(KC/SH/SB)09
5	Nonmetallic Mineral Products10	NP05(KC/SH/SB)10
5	Nonmetallic Mineral Products11	NP05(KC/SH/SB)11
6	Iron and Steel – Basic Industries1	NP06(KC/SH/SB)01

Table 3. Code of Petroleum Industries for Industrial Wastewater Database

Sr. No.	Industry Category	Sampling Code
1	Crude Petroleum and Natural Gas Products1	PT01(KC/SH/SB)01
1	Crude Petroleum and Natural Gas Products2	PT01(KC/SH/SB)02
1	Crude Petroleum and Natural Gas Products3	PT01(KC/SH/SB)03
2	Quarrying and Other Mining1	PT01(KC/SH/SB)01
2	Quarrying and Other Mining2	PT02(KC/SH/SB)02
2	Quarrying and Other Mining3	PT02(KC/SH/SB)03
2	Quarrying and Other Mining4	PT02(KC/SH/SB)04
3	Basic Industrial Chemicals except Fertilizer1	PT03(KC/SH/SB)01
3	Basic Industrial Chemicals except Fertilizer2	PT03(KC/SH/SB)02
3	Basic Industrial Chemicals except Fertilizer3	PT03(KC/SH/SB)03
3	Basic Industrial Chemicals except Fertilizer4	PT03(KC/SH/SB)04
3	Basic Industrial Chemicals except Fertilizer5	PT03(KC/SH/SB)05

2.3 Preparation of Database and Data Entry

All factories from which wastewater samples are being collected were coded as shown in column 3 of Tables 2 and 3. The first two letters of the code indicate the category of the industry: petroleum (PT) and non-petroleum (NP). The two digits after the category code represent industry type or specialization. The two letters after that refer to the location of the factory, which can be Kuwait City (KC), Shuaiba (SH), or Sabhan (SB) area. The two digits after the factory location code indicate the serial number of the factories of the same type or specialization industry from which wastewater samples will be collected. ArcGIS is now the most used mapping and spatial analytic software in all over the world. It is used by both governmental and private sectors. In Kuwait, the GIS Department of KISR uses mainly ArcGIS to develop geographic information maps. Accordingly, Excel spread-sheet database was prepared and was continuously updated with obtained laboratory results. Finally, ArcGIS software was used to convert the Excel database into GIS database, from which a number of GIS maps were produced.

3 RESULTS AND DISCUSSION

The obtained results from the field surveys were categorized and divided into petroleum and non-petroleum industries (Table 4). Also, the field survey indicated that limited number of factories used on-site treatment systems or recycled or reused the industrial wastewater.

Table 4. Industry Categories for Petroleum and Non-Petroleum Sectors

No.	Industry Name	Industrial Area	Industry Category	Petroleum and Non-Petroleum Sectors
1	Kuwait Aluminum Extrusion Company	Sabhan	Aluminum Forming	Non-Petroleum
2	Al-Mejhem Global Group Company	Sabhan	Grain Mills Manufacturing	Non-Petroleum
3	Gulf Insulating Material	Sabhan	Manufacturing Insulated Wire	Non-

	Plant Company		and Cable	Petroleum
4	Gulf Insulating Material Plant Company	Sabhan	Manufacturing Insulated Wire and Cable	Non-Petroleum
5	Arab Western Industries Company	Sabhan	Basic Industrial Chemicals	Petroleum
6	Refreshment Trading Company (Coca Cola)	Sabhan	Soft Drinks and Carbonated Water Industries	Non-Petroleum
7	Kuwait Flour Mills and Bakery Company	Sabhan	Manufacturing of Bakery Products	Non-Petroleum
8	Kuwait Indo Trading Company	Sabhan	Manufacturing of Food Products	Non-Petroleum
9	Middle East Manufacturing Company	Sabhan	Basic Industrial Chemicals	Petroleum
10	Kuwait United Poultry Company	Sabhan	Slaughtering and Preserving Meat	Non-Petroleum
11	Naif Poultry Company	Sabhan	Slaughtering and Preserving Meat	Non-Petroleum
12	Gulf Pastries Manufacturing Co. (Sara Cake)	Sabhan	Manufacturing of Bakery Products	Non-Petroleum
13	The Plastic Company	Sabhan	Basic Industrial Chemicals	Petroleum
14	Carpet Industry Company	Sabhan	Manufacturing of Textile Goods	Non-Petroleum
15	Al-Hadaf Newspaper	Kuwait City	Printing, Publishing, and Allied Industries	Non-Petroleum
16	Printing and Publication Office, KISR	Kuwait City	Printing, Publishing, and Allied Industries	Non-Petroleum
17	Kabad Research Plant, KISR (Sheep Farms)	Kuwait City	Concentrated Animal Feeding Operations	Non-Petroleum
18	Kabad Research Plant, KISR (Goat Farms)	Kuwait City	Concentrated Animal Feeding Operations	Non-Petroleum
19	Kuwait United Diary Company	Kuwait City	Dairy Products Processing	Non-Petroleum
20	Kuwait Diary Company	Kuwait City	Dairy Products Processing	Non-Petroleum
21	Salmiya Slaughtering Company	Kuwait City	Slaughtering and Preserving Meat	Non-Petroleum
22	Shuwaikh Slaughtering Company	Kuwait City	Slaughtering and Preserving Meat	Non-Petroleum
23	ABJ Engineering and Contracting Company	Shuaiba	Iron and Steel Manufacturing	Non-Petroleum
24	ACICO Construction Co.	Shuaiba	Cement Manufacturing	Non-Petroleum

The GIS produced maps with summaries of ranges of wastewater quality parameters for factories participating in the sampling campaign are shown in Figs. 2 to 3 for each industrial area. The average parameters of each industrial area are shown in Table 5 and Fig. 4.

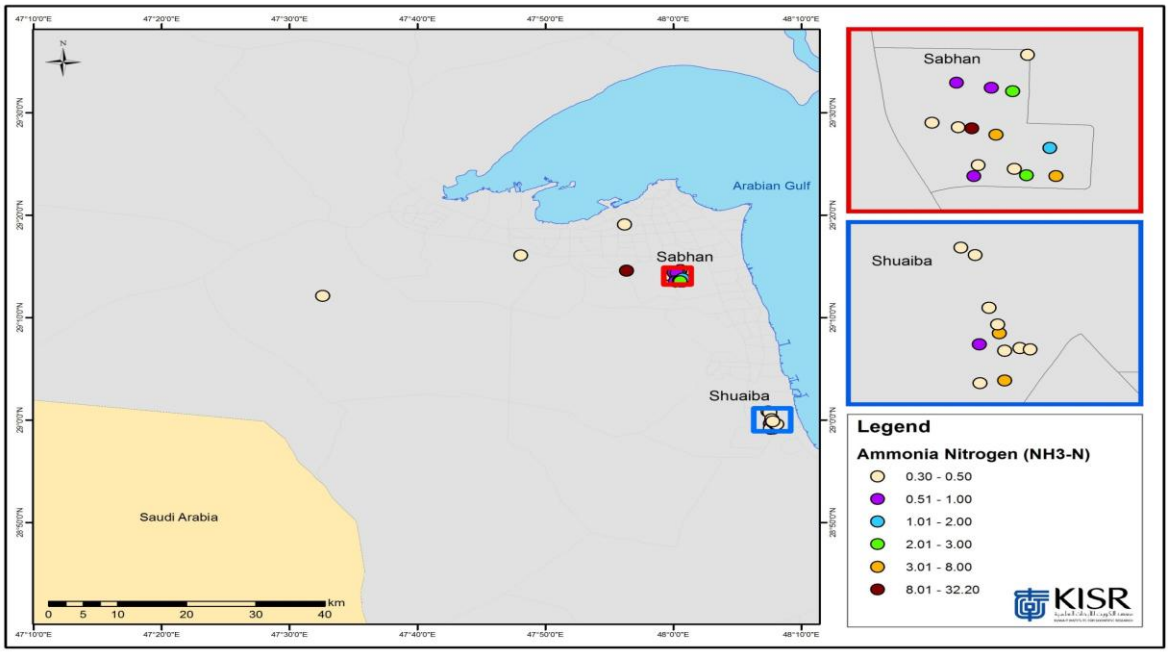

Figure2. Distribution of Ammonia Nitrogen for Various Industries in Kuwait.

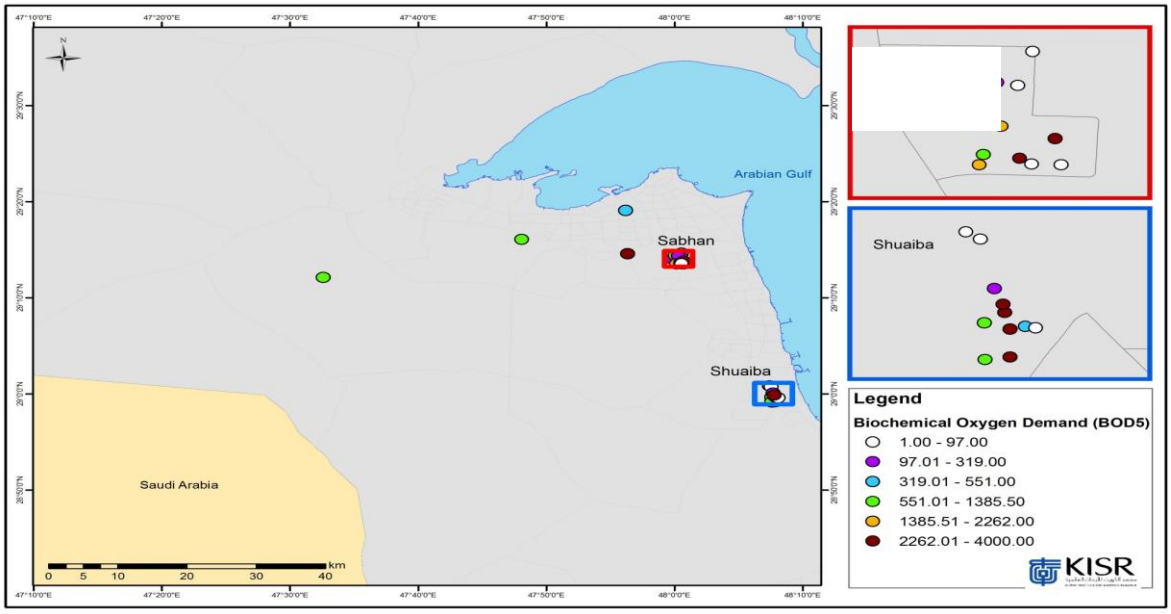

Figure 3. Distribution of Biochemical Oxygen Demand for Various Industries in Kuwait

Table 5. Average Wastewater Parameters for Each Industrial Area Classified by Categories of Industry (P-Petroleum, NP-Non Petroleum).

Parameter	Area					
	Sabhan		Kuwait City		Shuaiba	
	NP	P	NP	P	NP	P
pH	7.106666667	7.53	6.546		8.211666667	9.13
Dissolved Oxygen (DO)	3.915	3.78	0.673333333		3.586666667	1.49
Total Suspended Solids (TSS)	47.8	1.3	1526.226		327.1666667	4968.5

Total Dissolved Solids (TDS)	421.5833333	142	9957.12		6808.416667	1782
Floatables	NA	NA	NA	NA	1.4	NA
Total Phosphate (TPO43-)	22.64166667	0.1	109.31		28.38333333	2.4
Ammonia Nitrogen (NH3-N)	8.866666667	NA	17.65		2.866666667	3.1
Total Nitrogen (TN)	16.41666667	7.5	120.7		8.23	39.5
Sulfide (S2-)	0.19125	0.07	0.4738		0.2794	0.7025
Fluoride (F-)	1.2025	0.4	6.255		0.796666667	0.32
Total Oil & Grease (TOG)	21.5	NA	53.1		93	63.75
Total Petroleum Hydrocarbons (TPH)	2.5	NA	0.5		47.5	54.5
Total Organic Carbon (TOC)	77.99383333	4.96	102.812		86.045	26.05
Biochemical Oxygen Demand (BOD5)	311.75	6.5	1156.5		1170.6	22.5
Chemical Oxygen Demand (COD)	509.25	10.5	4036.5		3308.25	5241.5
Free Chlorine (FCl2)	0.087	0.06	0.245		0.173	0.007
Phenol	0.01975	NA	0.116666667		0.0725	0.061
Surfactants (Anionic)	NA	NA	NA	NA	NA	NA
TKN	15.315	6.59	117.774		11.07333333	36.22
Temperature	24.76666667	NA	NA	NA	25.075	27.5
EC	499.8333333	NA	NA	NA	4.95125	2.94
Eh	93.83333333	NA	NA	NA	89.75	-35

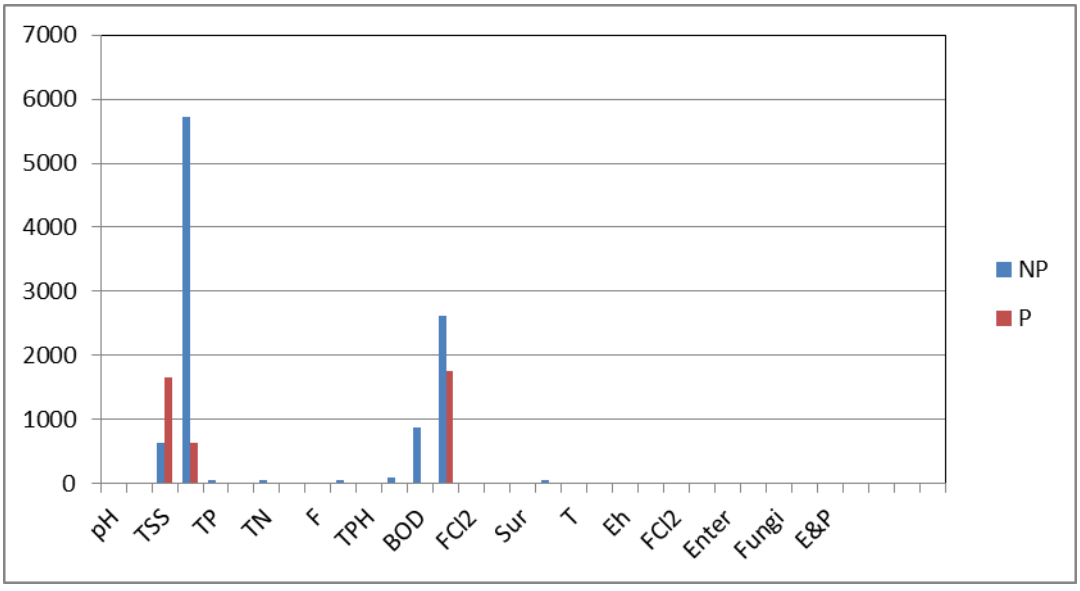

Figure 4. The overall average for selected parameters (mg/l) classified as petroleum (P) and non-petroleum (NP).

It is evident from Table 5 and Fig.5 that the pH and DO are much lower for P vs NP indicating acidic conditions and slightly anaerobic conditions of the P industries so far in the sampling campaign. The acidic conditions is also supported by the higher free chlorine in the P industries.

However on the TSS, BOD, COD, TOC and many other pollutants are higher in the NP industries. Although this result may seem paradoxical, however, it indicates better process control.

4 CONCLUSIONS

A field study was carried out to collect data on the quality and quantity of petroleum and non-petroleum industrial wastewater from different sources in Kuwait and developing a database for the target industries using ArcGIS technique. A total of 75 field visits were conducted in three industrial areas in Kuwait, namely, Sabhan, Kuwait City, and Shuaiba Industrial Areas. Industrial wastewater samples were collected and analysed for physical, chemical organic and microbial parameters. The obtained field results indicated that the activities of these industries can be compartmentalized under 20 industrial categories including 11 and 37 petroleum and non-petroleum industries, respectively. Furthermore, the obtained field data suggest that only a few industries use on-site wastewater treatment systems. The preliminary laboratory results indicated that pH and DO values in the petroleum industries were lower than those of nonpetroleum industries while organic parameters (BOD, COD, TOC) values were higher in nonpetroleum industries compared with petroleum industries. Based on the field, laboratory and GIS results, following recommendations are forwarded:

1. Collection data regarding quantity y and quality of industrial wastewater for petroleum and nonpetroleum sectors should be continue for long monitoring period and for all parameters.
2. The development of industrial database should be updated every two years by Public Authority Industry (PAI).
3. Onsite treatment systems should be installed to treat the industrial wastewater for group of industries of similar sources.

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