WASTEWATER INDUSTRIAL DATABASE FOR SABHAN AREA 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. 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. In this study, Wastewater and wastewater samples were collected and analysed on monthly and biweekly basis from 14 non-petroleum factories of Sabahan industrial areas. This paper was targeting assessment of total phosphate in the raw wastewater for factories of Sabhan industrial area. The field wastewater data indicated presence slightly acid to slightly alkaline (4.9-10.8), reduced to oxidized environment (-410 mv-538 mv) and freshwater to brackish water (120µS/cm-8,673µS/cm). The laboratory results revealed that total phosphate concentrations for wastewater of 14 factories ranged between 0.1 mg/l and 104 mg/l. The mean values of total phosphate concentrations for wastewater of 14 factories were meeting the maximum limit (30 mg/l) set by KEPA for irrigation water purposes except those values of PO_4 (>30 mg/l) for three factories. The mean value of quantities of wastewater generated from 14 factories was found 55,894 m^3/week. The large quantities of raw wastewater generated from these factories can be used safely as irrigation water with respect to total phosphate concentrations.

Keywords: Sample collection, laboratory results, field survey, non-petroleum and phosphate.

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. 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 aims is to evaluate the concentrations of different total phosphate (PO_4) in raw wastewater generated from 14 non-petroleum factories of Sabhan industrial area, to determine quantizes of wastewater generated and to draw distribution maps for phosphate concentration for wastewater generated from these factories using GIS technique

2 METHODOLOGY

2.1 Survey of Industries

In this study, 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. Total of 14 factories were selected to determine the quality and quantity of wastewater from Sabahan industrial area. Fig. 2, represents location maps for these factories. Summary of the factory names, sampling codes along with coordinates were presented Table 1.

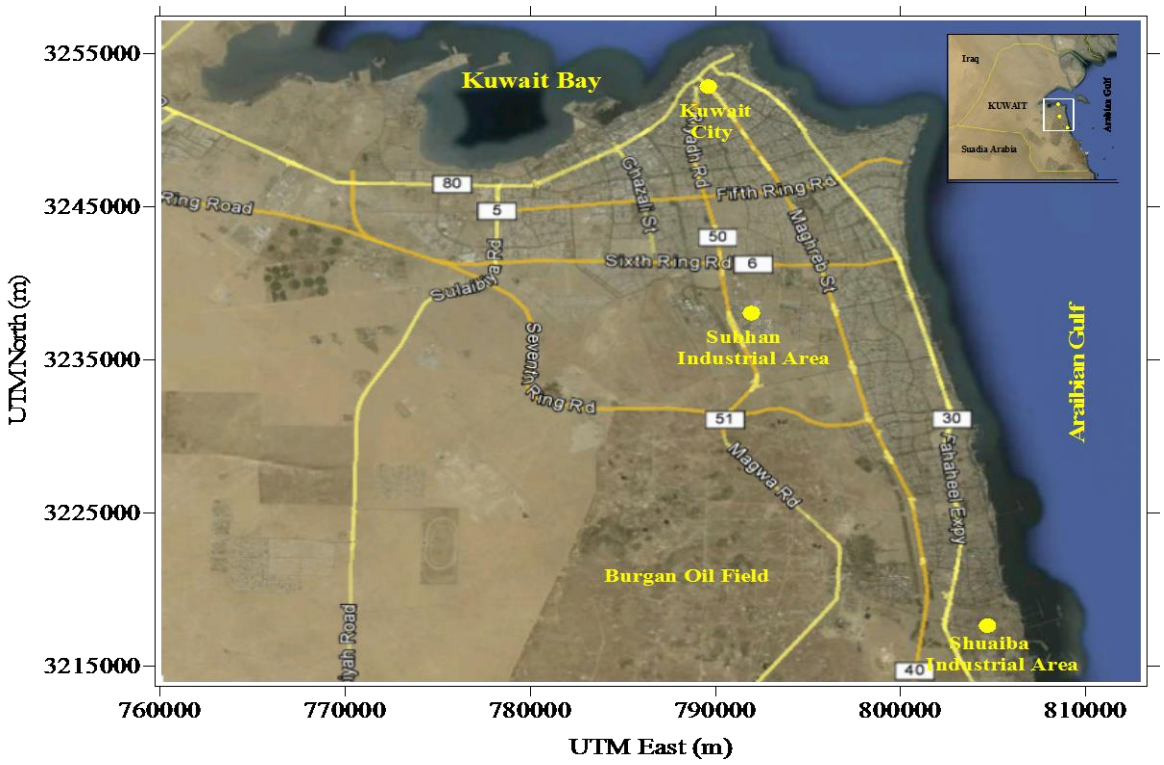

Figure 1. Location map of the study area.

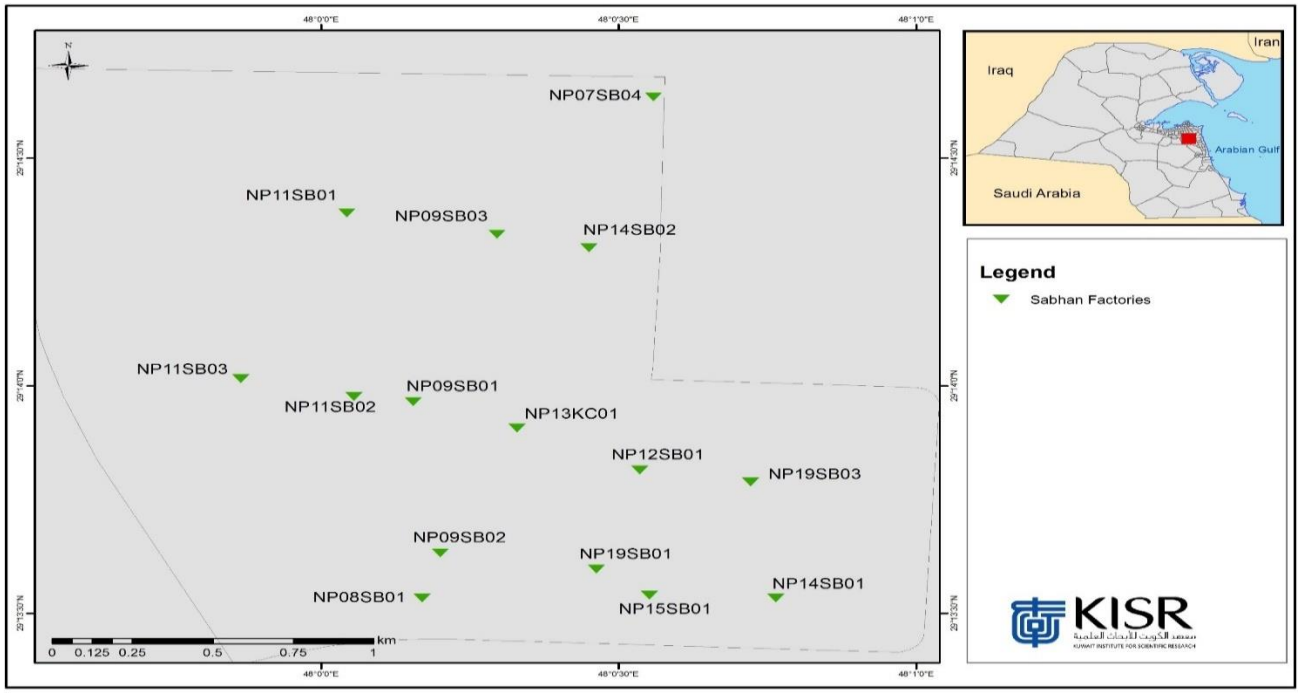

Figure 2. Location map of selected factories at Sabhan industrial area.

Table 1. Summary of Selected Factories Names, Codes and Coordinates at Sabahan Industrial Area

Serial No.	Factory/Site name	Sample Code	Factory/Site Coordinates (UTM)	
			North	East
1	Al-Yasra Company	NP07-SB04	29.2438987	48.0093041
2	Petra Food Manufacturing Company	NP08-SB01	29.2255592	48.0028326
3	Al-Mejhem Global Group Company	NP09-SB01	29.2327471	48.0025814
4	Kuwait Flour Mills and Bakery Company	NP09-SB02	29.2272129	48.0033348
5	Gulf Pastries Manufacturing Company	NP09-SB03	29.2388726	48.0049314
6	Refreshment Trading Company (Coca Cola)	NP11-SB01	29.2396461	48.0007190
7	United Beverage Company (Pepsi)	NP11-SB02	29.2329353	48.0009185
8	Al-Sayer Soft Drink Factory (RC Cola)	NP11-SB03	29.2335895	47.9977508
9	Carton Industries Company	NP12-SB01	29.2302470	48.0089239
10	Gulf Insulating Material Plant Company-1	NP14-SB01	29.2255583	48.0127323
11	Gulf Insulating Material Plant Company-2	NP14-SB02	29.2383767	48.0075050
12	Kuwait Aluminum Extrusion Company	NP15-SB01	29.2256665	48.0091978
13	Al-Bahar Industries	NP19-SB01	29.2266184	48.0077132
14	Sabahan Factory	NP19-SB03	29.2298120	48.0120292

Note: UTM-Universal Transverse Mercator

2.2 Industrial Wastewater Sampling and Laboratory Analysis

Based on the field surveys of the targeted industries, wastewater sampling and associated measurements was determined. The measurements and sampling started for all factories in mid-December 2018 on a monthly basis during the period between mid-December 2018 and end of April 2019, as instructed by the owners of factories, followed by biweekly sampling during June–July 2019. The samples were collected using bailers from wastewater collection points. Prior to sampling, wastewater field measurements, including, temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), and oxidation reduction potential (ORP), were carried out for all sites. 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). Wastewater parameters were analysed according to standard methods for the examination of water and wastewater (APHA, 2017). In the data analysis section, the laboratory results of the wastewater samples was compared with local standards (KEPA, 2017) for irrigation water standards.

2.3 Wastewater Quantities

The quantities of freshwater consumption inside each plant measured near flow meter gage, and these data were collected from owners of the factories while the raw industrial wastewater was measured through calculating number of sewage takers (each tanker with capacity 5,000 gallons) discharged per week from each factory.

3 PREPARATION OF DATABASE AND DATA ENTRY

To develop a site coding, the industries were first divided into two main groups: petroleum and non-petroleum industries. The abbreviations PT was used to indicate the petroleum group of industries while the abbreviation NP to indicate non-petroleum group of industries. Each of the two main groups of industries (PT and NP) was then subdivided into subgroups. A two-digit code was then assigned for each sub-group. Coordination of the industrial site studied were measured in Universal Transverse Mercator (UTM) system, North and East. Table 1 shows the codes and the UTM coordinates of the 14 industrial factories that agreed to participate in the study. Excel spread-sheet was prepared as a database in which values of field measurements (Temperature, DO, EC, ORP, and pH) and the wastewater quality parameters determined in the lab were regularly entered and updated. The Excel database was then converted into a GIS database, using ArcGIS software. From the GIS database, GIS maps for each wastewater quality parameter have been generated to help in analyzing the spatial distribution of the quality of the raw wastewater produced by the various factories.

4 RESULTS AND DISCUSSIONS esults and

The quantities of freshwater consumption and wastewater generated from each industry were presented in Fig. 3. The maximum, mean and minimum values of freshwater consumption for 14 factories of Sabahan industrial areas were found to be 110,535m^3/week 9,073m^3/week and 33m^3week, respectively. The highest freshwater consumption was found with Kuwait Flour Mills Company. Total of 127,027m^3/week of freshwater was consumed by 14 factories. On the other hand, The maximum, mean and minimum values of wastewater produced by 14 factories of Sabhan industrial areas were found to be 420,000m^3/week, 55,894m^3/week and 20m^3/week, respectively. The highest wastewater generated was found with Refreshment Trading Company. Total quantity of 782,520m^3/week of raw wastewater was generated by 14 factories (Fig. 3).

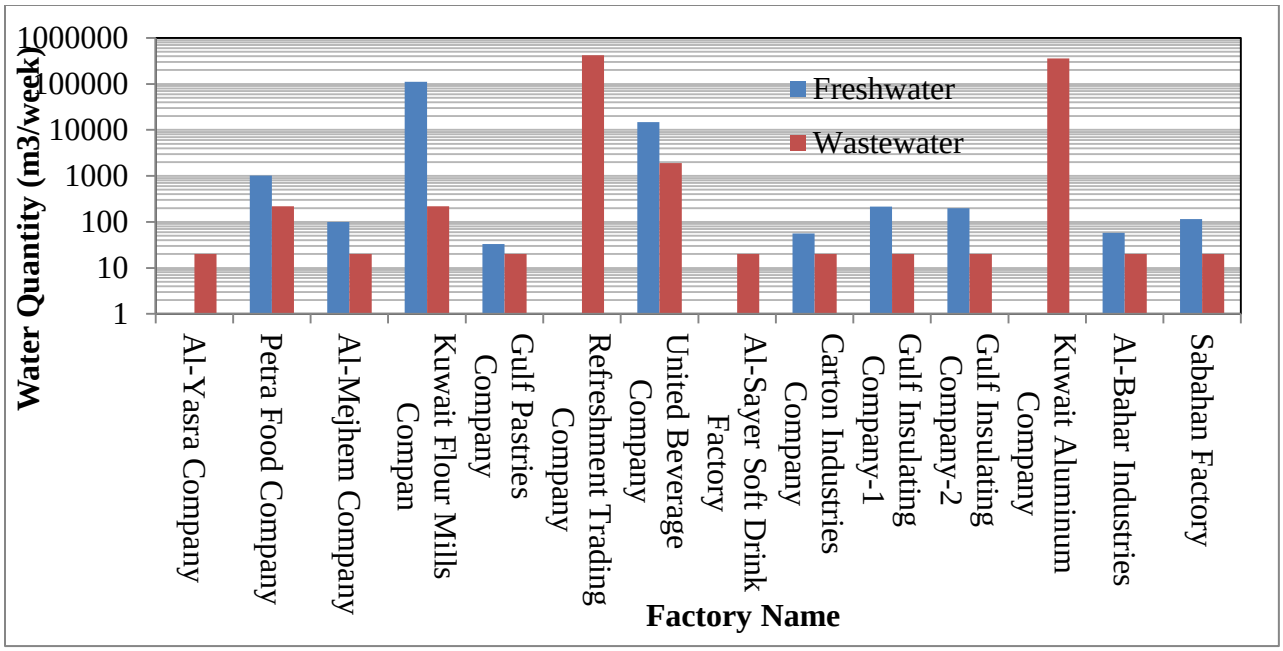

Figure 3. Quantities of freshwater and wastewater for each factory of Sabahan industrial area.

The pH is field parameter provides information about of wastewater environment if it is acidic, neutral or alkaline media associated with certain dissolved gases in that media. Lower limit (6.5) and upper limit (8.5) were set for pH parameter of wastewater by Kuwait EPA for irrigation water purposes. The maximum, average and minimum values of wastewater pH for 14 factories of Sabhan area were plotted in Fig. 4. Except five factories (Al-Yasra, Al-Mejhem, Insulatine-2, Aluminum and Al-Bahar) where wastewater pH were found alkaline, the wastewater pH for the remaining factories represent acidic environment. The mean values of pH of wastewater for eight companies (Petra, Flour, Pastries, Coca Cola, Pepsi, RC Cola, Carton and Al-Bahar) do not meet either the lower or upper limits set by KEPA for irrigation water standard.

Electrical conductivity of wastewater was measured to estimate the salinity of wastewater (represented by TDS values) in the field. The minimum and maximum values of electrical conductivity of wastewater of 14 factories was found to be 174 µS/cm and 8673 µS/cm, respectively (Fig. 5). The average values of electrical conductivity (lower than 550 µS/cm) of wastewater for all factories categorized as freshwater type except the mean values of electric conductivity (3156 µS/cm) of wastewater of Al-Bahar Company which characterized as brackish water type..

The oxidation reduction potential values of the wastewater ranged between -410.0 mv and 538.0 mv for the 14 factories. The ORP values of the wastewater of total of eight factories indicated reduced environments while the ORP values (below 0.0 mv) for the wastewater of the remaining factories (Al-Yasra, Insulating-1, insulating-2, Aluminum, Al-Bahar and Sabhan) indicated oxidized environments (above 0.0 mv) as shown in Fig.6. The negative values of ORP values might be due to presence of number of reduced gases such as ammonia, methane, hydrogen sulfide and volatile organic compounds in the raw wastewater.

The dissolved oxygen (DO) values of the wastewater ranged between 0.0 mg/l and 8.6 mg/l for the 14 factories. The same eight factories with reduced ORP values of the wastewater had 0.0 mg/l DO while the DO values (below 0.0 mv) for the wastewater of the remaining indicated oxidized environments (above 0.0 mv) as shown in Fig.7. The mean values of DO of wastewater for eight companies (Petra, Flour, Al-

Mejhem, Pastries, Coca Cola, Pepsi, RC Cola and Carton) do not meet the Maximum limit set by KEPA for irrigation water standard.

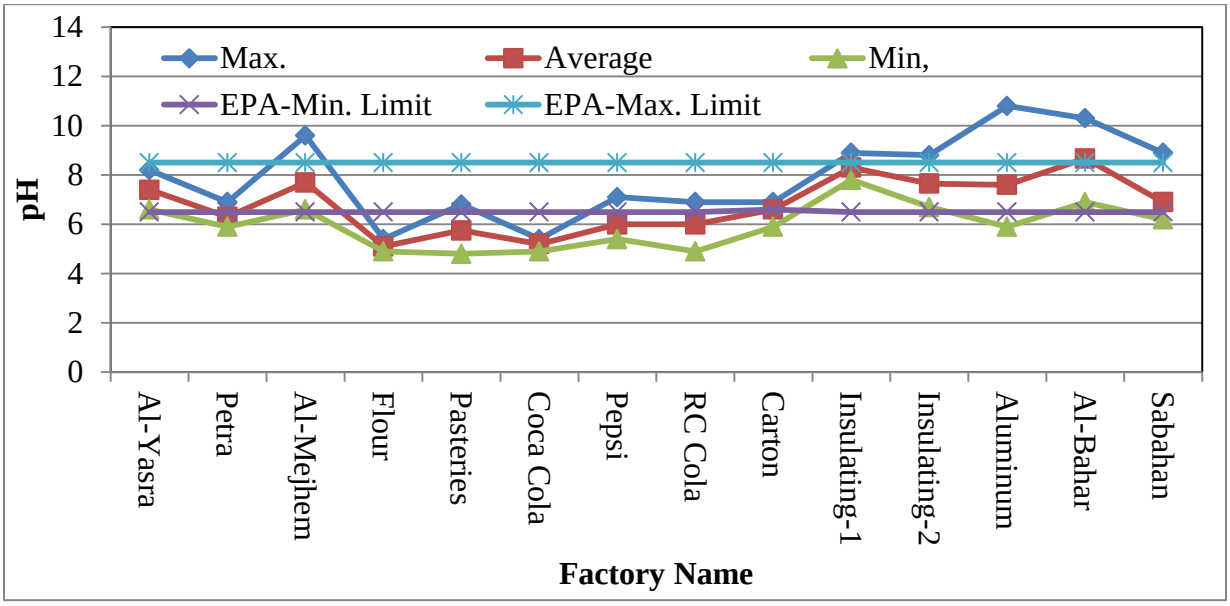

Figure 4. Changes in pH values of wastewater for Sabhan factories.

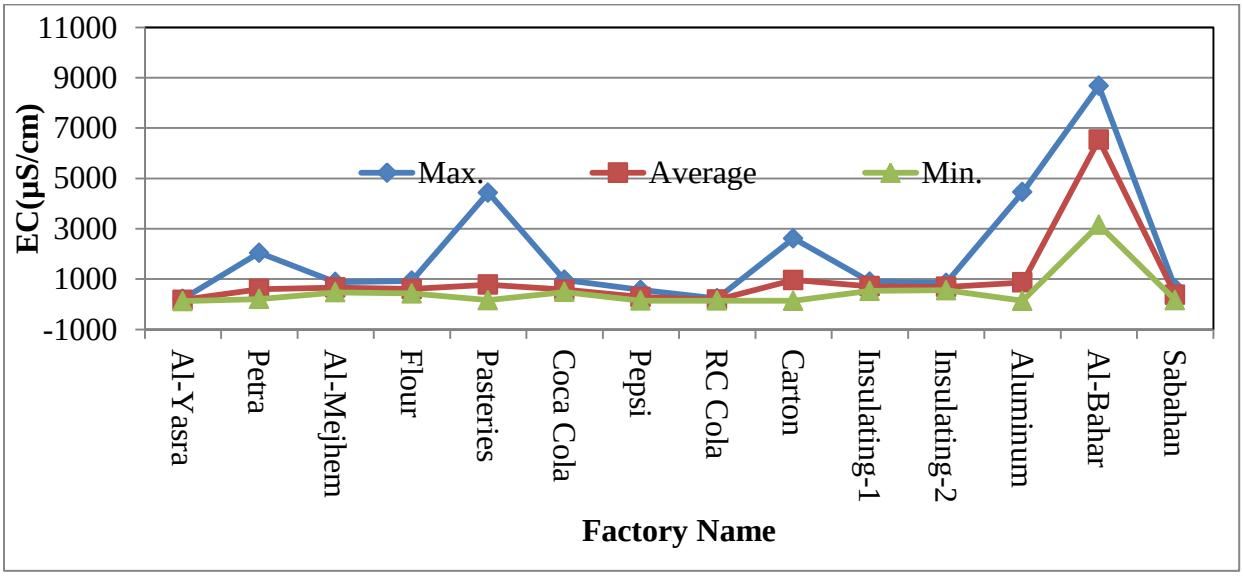

Figure 5. Changes in electrical conductivity values of wastewater for Sabhan factories.

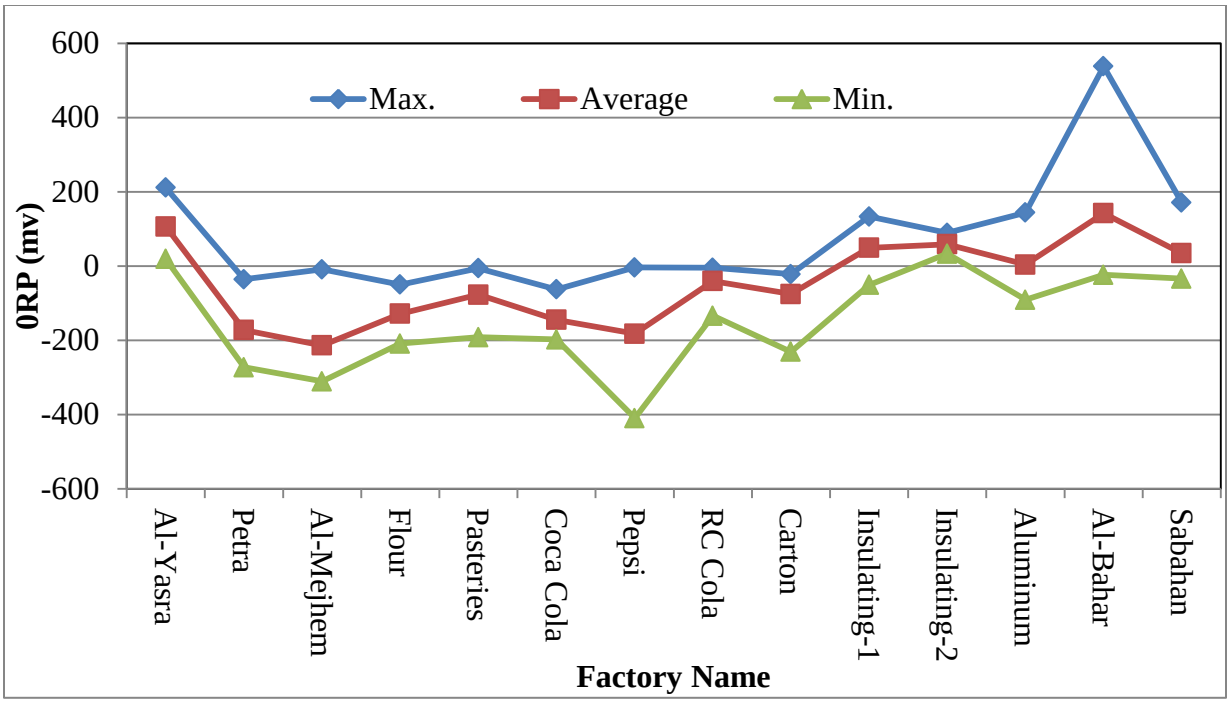

Figure 6. Changes in oxidation reduction potential values of wastewater for Sabhan factories.

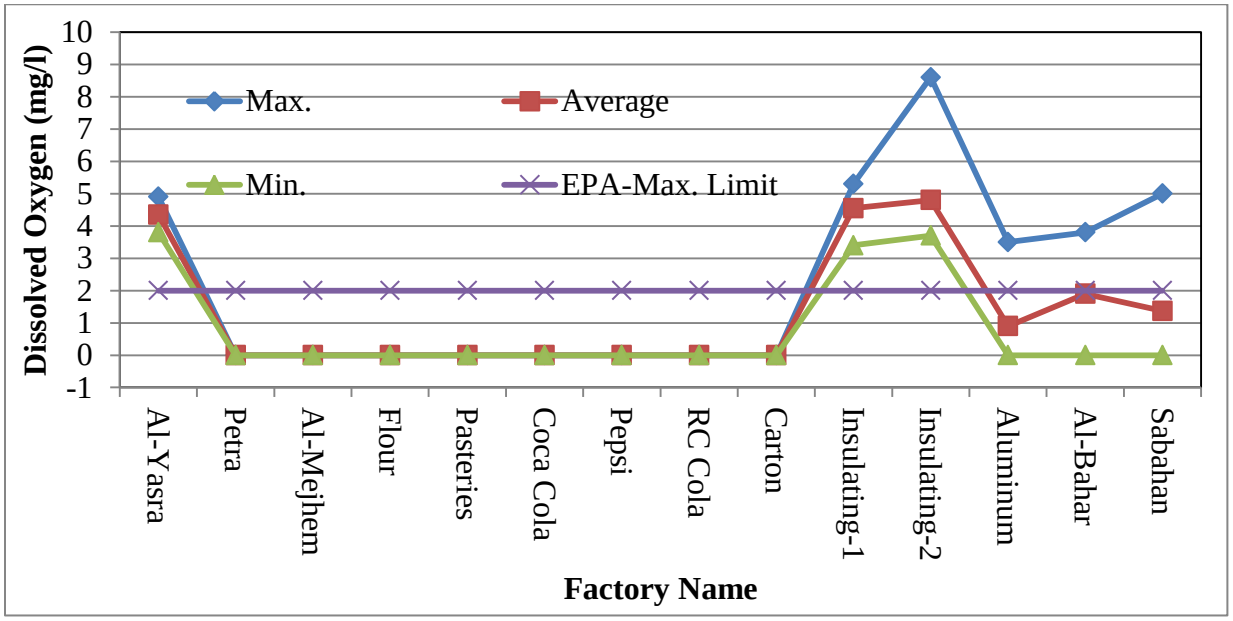

Figure 7. Changes in dissolved oxygen values of wastewater for Sabhan factories.

The total PO_4 value of 30 mg/l were set by KEPA as maximum limits for irrigation water. Phosphate also is considered as nutrient and essential element for plant growth. The total PO_4 values of the wastewater ranged between 0.1 mg/l and 104 mg/l for the 14 factories as shown in Fig.8. All average values of total PO_4 0f the wastewater meet the maximum limit set by KEPA for irrigation water purposes except those values of PO_4 (>30 mg/l) for three factories (Petra, Insulating-1 and Al-Bahar) and this parameter should be treated. Distribution GIS maps were generated for PO_4 based on the data of GIS

database using ArcGIS software as shown in in Figs.9-11. Sabhan area results were shown in top red square in Figs. 9-11.

Total of five factories (Al-Sayer soft drinks, Gulf Insulating Material Plant Co.-1, Gulf Insulating Material Plant Co.-2, Kuwait Aluminum Extrusion Company and Al-Bahar Industries Co.) used on site treatment system in Sabhan industrial area. The water treatment system varied between pH control and ion exchange water treatment units. The remaining factories send the untreated wastewater to Wafra Industrial wastewater Treatment Plant (WIWWTP).

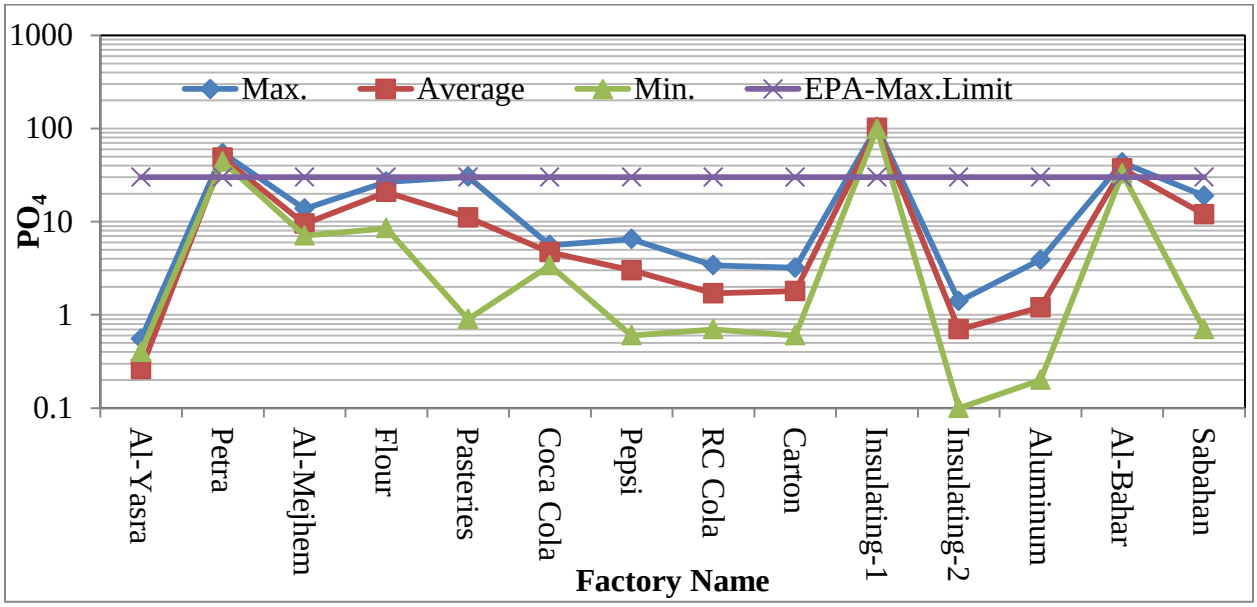

Figure 8. Changes in phosphate values of wastewater for Sabhan factories.

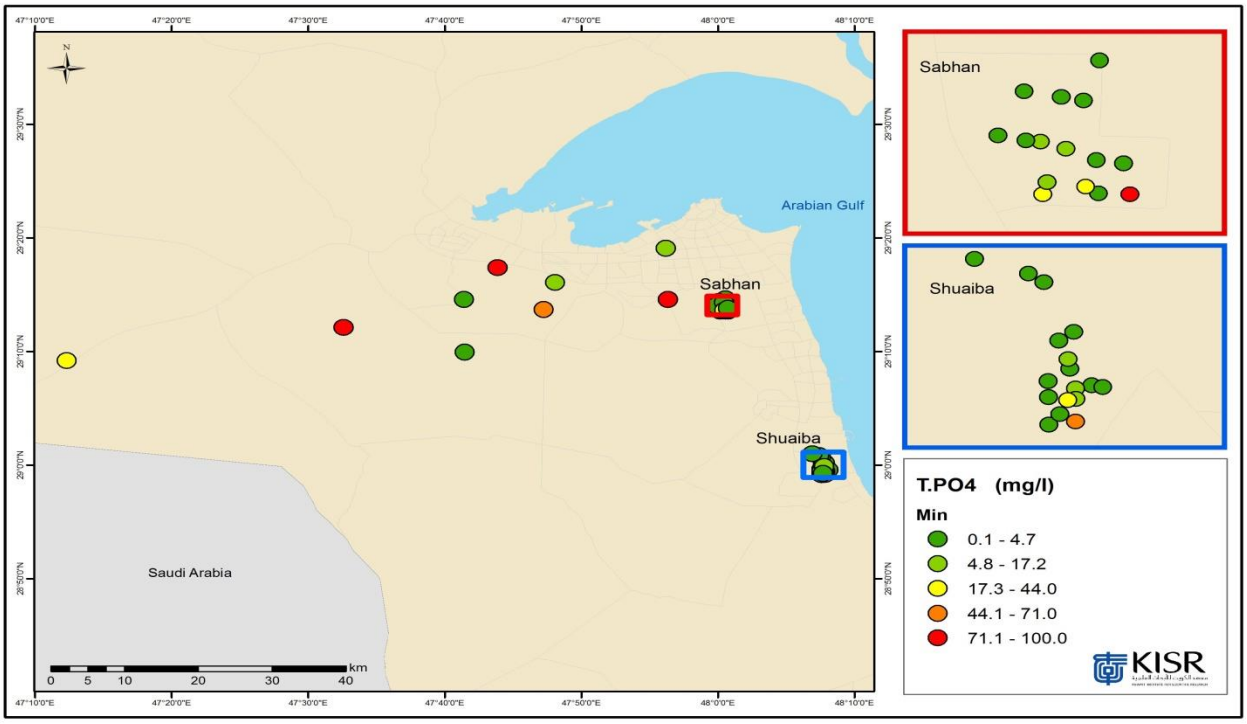

Figure 9. Distribution map of minimum values of total phosphate (mg/l) in wastewater for various industries in Kuwait.

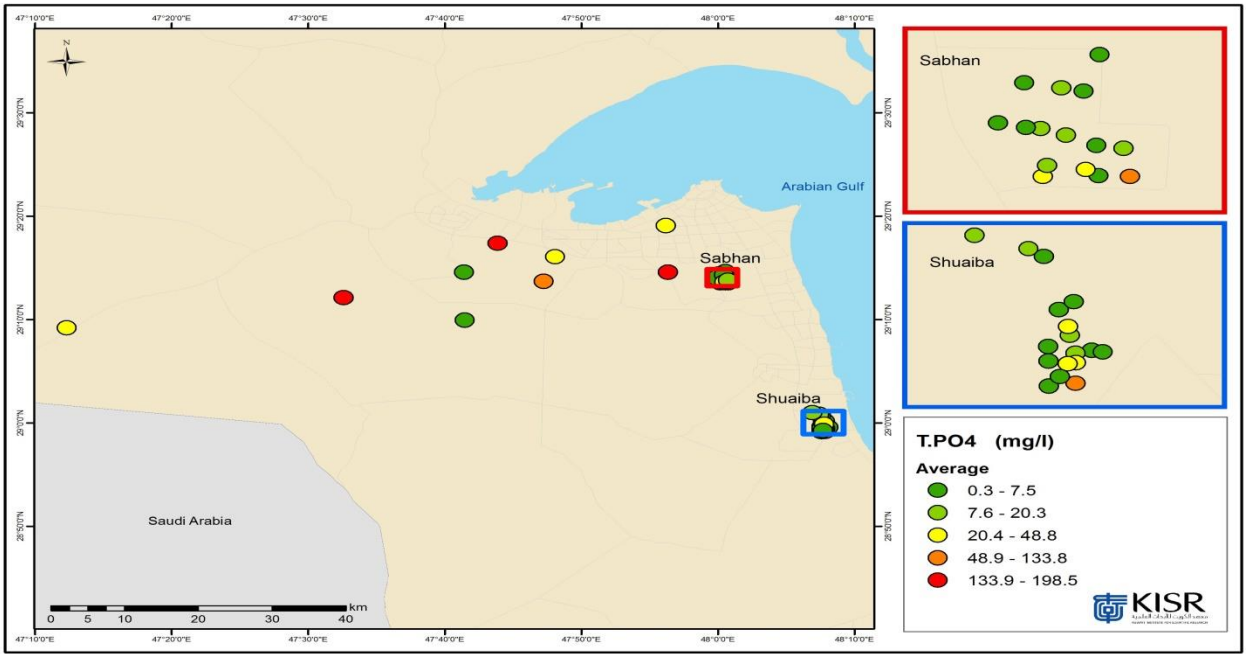

Figure 10. Distribution map of average values of total phosphate (mg/l) in wastewater for various industries in Kuwait.

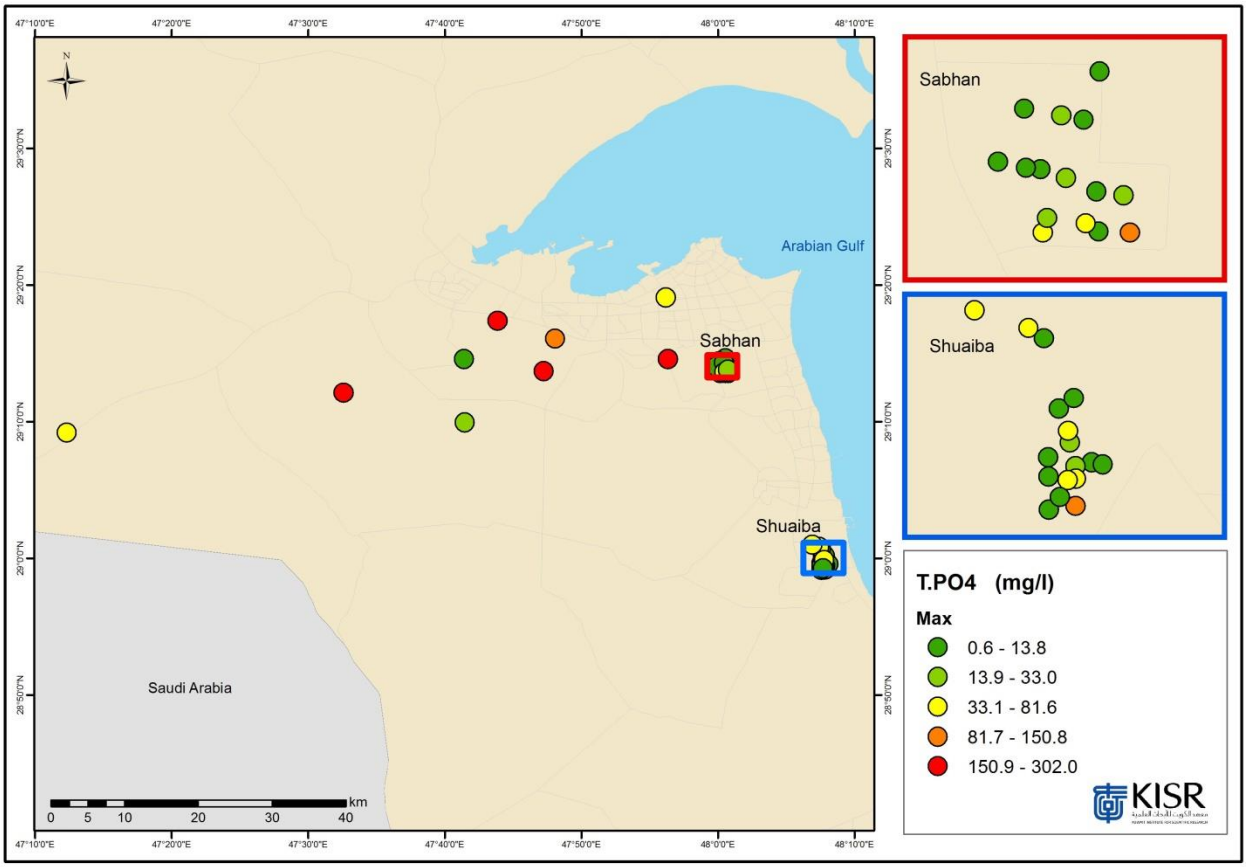

Figure 11. Distribution map of maximum values of total phosphate (mg/l) in wastewater for various industries in Kuwait.

CONCLUSIONS

A field study was carried out to collect data on the quality and quantity of wastewater from 14 non-petroleum factories of Sabhan industrial area, and developing a database for the target industries using ArcGIS technique. Wastewater samples were collected and analysed for chemical parameters. The laboratory results of total phosphate indicated that their concentrations in the raw wastewater are meeting KEPA irrigation water standards except for those values of PO_4 (>30 mg/l) for three factories (Petra, Insulating-1 and Al-Bahar). Also, the obtained field data suggest that only a few industries use on-site wastewater treatment systems. Based on the field, laboratory and GIS results, following recommendations are forwarded:

1. Collection data regarding quantity 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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