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Upshot of Industrial Effluent on Groundwater Quality by Using Water Quality Indices

Aziz-ur-Rahman* and Iqbal H. Hashmi
Department of Energy and Environment, Hamdard University Campus-II, Karachi, Pakistan.

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**Corresponding Author. E-mail: azizemaz@yahoo.com; Tel: (+922136988024)*

Abstract
Groundwater is one of the most precious natural resource that needs to be protected from deterioration. Seepage of industrial and extensive pumping has caused serious qualitative and quantitative problems in the aquifer. Therefore, hydro-chemical investigation was carried out to understand the groundwater quality through the use of WQI approach in Sindh Industrial Trading Estate area, Karachi, Pakistan. Samples were collected and analysed for major ions (Cations and Anions). Water quality range was calculated to quantify overall groundwater quality. This study suggested that most of the groundwater samples of the area are having non-consumable quality standards due to effective leaching of industrial effluent and over exploitation of groundwater.

Keywords: Groundwater, Physico-chemical parameters, Industrial effluent, Water quality index.

1. Introduction
With the growing demand for water and declining freshwater resources especially in developing countries like Pakistan, the utilization of marginal quality groundwater has posed a new challenge for environmental management. Groundwater is usually considered a good source of drinking water, because of the intrinsic purification characteristic of the soil. Conversely it is also flat to be polluted through leaching from industrial activities, poor sanitation, and dumpsites etc [1- 4]. The sources of ground water pollution are greater than before by the result of certain hydrological setting such as shallow aquifer and permeable soil [5, 6]. In addition to this, changes in natural ground cover, land development and soil compositions alter the amount and rate at which Industrial waste water infiltrates [7- 12]. Water contamination is a growing hazard in many developing and under developing countries including Pakistan. A polluted environment has a detrimental effect on the health of people and routine functioning of ecosystem [13]. Available research reports site gross contamination of Ground water in Pakistan by discharge of industrial effluents, sewage, and agricultural runoff among others, which will further intensify the demand for safe drinking water increases [14]. In arid and semi-arid region, due to scarcity of inland water, there is reliance on groundwater to a large extent. No detail studies have been reported with respect to industrial effluent on groundwater with the exception of few such as impact of Heavy metals as a result of industrial effluent seepage of these industries in the groundwater of SITE and its adjoining residential area [15]. This study was initiated to evaluate the impact of industrial effluents on the quality of ground water in the surrounding area to know if the industrial effluents had any effect on the contamination of such water, used for drinking or industrial use. In addition, water quality index is also use to evaluate groundwater quality status [16-19].

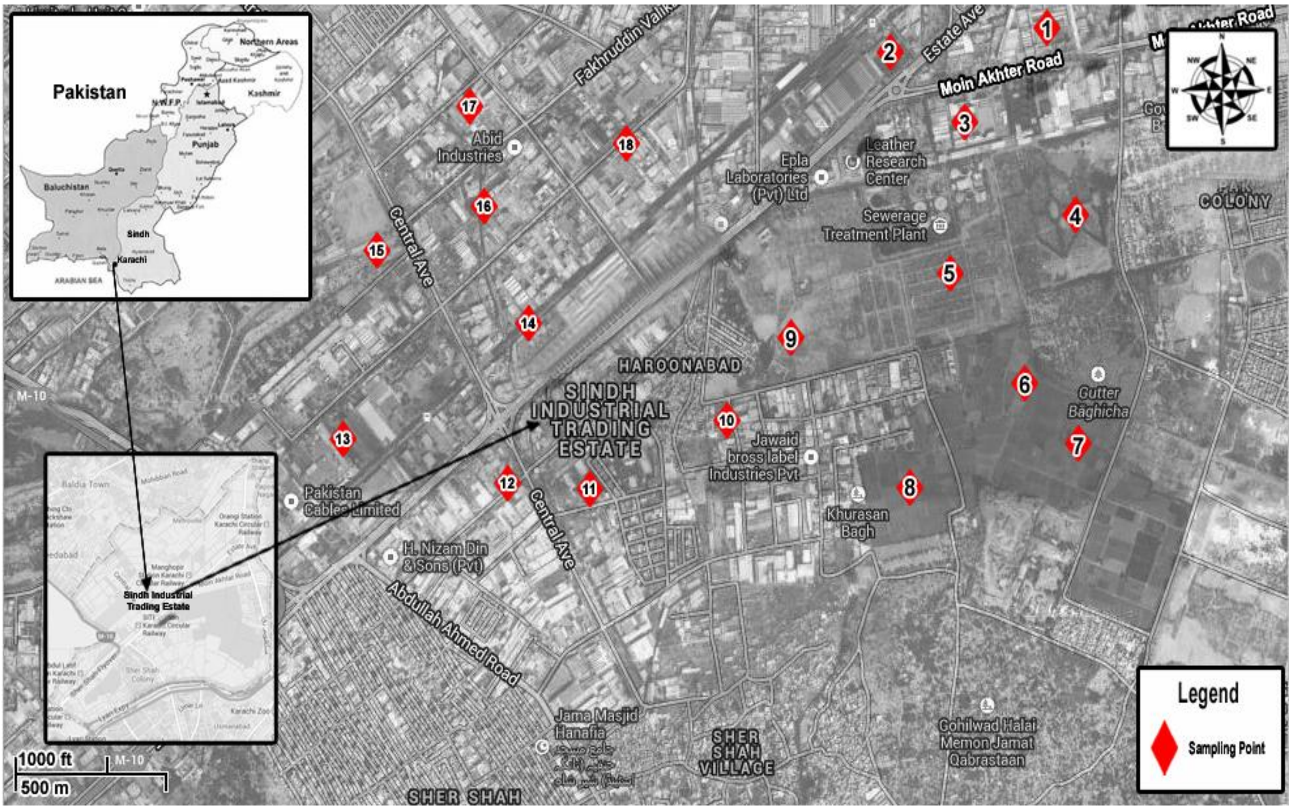
2. Material and methods
2.1. *Study area*
The Sindh Industrial Trading Estate is located in the north and north-eastern part of the city Karachi, Pakistan in the vicinity of residential area. More than 2600 industries are in operations which are of various natures such as Textile, edible oil/ghee, Pharmaceutical, printing and dying, food and beverages, detergents, Electroplating and etc. Industrial effluents of these industries being disposed into waste drains and other water bodies are common in industrial SITE area. At some places, where there are no waste drains, industrial

effluents are discharged directly into the groundwater, through an excavation in the soil serving as a soak pit, causing direct pollution of groundwater such as at SITE industrial trading estate, Karachi, Pakistan.

2.2. Site Location

The location map of study area is represented in figure 1.

Figure 1: A Layout and sampling point of study area



2.3. *Sampling and physicochemical analysis*

Eighteen (18) representative samples of groundwater were collected twice during a calendar year 2013(once during day and once in night) in sterile 1500ml polyethylene bottles from SITE industrial trading estate. All the samples were instantly shifted to the analytical Laboratory for various physico-chemical parameters according to international standard methods [20]. The analysed test results were verified for electro-neutrality. Correlation, mean and standard deviation were calculated by using Statistical Package for social Scientist (SPSS) 14th version.

2.4. *Water quality index (WQI)*

A number of water quality indices such as NPI, WQI and %Na have been formulated and are employed time to time [21]. These indices serve as a tool to convert a large set of data into a much reduced and enlightening form. Among these WQI is a well rating technique that provides the composite influence of individual water quality parameter on the overall quality of water and its suitability for drinking purpose [22]. WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, poor, etc.) for reporting to management and the public in a consistent manner [23]. In this study Weighted arithmetic index method was used for calculating WQI [24].

3. Results and discussion

3.1. *Wastewater characteristics*

Descriptive statistic of physico-chemical values generated from the analysis was presented in Table 1. This data was compared with WHO (1993) and NEQS (National Environmental Quality Standard, Pakistan 2000)and tabulated in Table 2. In the entire study period, the pH ranges was 7.23 to 8.73 and mean value was

8.02. TDS range was found in the range 1139.60 to 15180.0 and with mean value in the range 3376.5. Calcium, Magnesium, Sodium and Potassium content were detected in the range of 17.6 to 379.5, 9.9 to 364.10, 280.5 to 4623.3 and 3.85 to 29.70 and their mean values in the range 78.7, 86.7, 936.5 and 11.13 respectively. Chloride, Sulphate, Nitrate and hydrogen bicarbonate were found in the range 211.2 to 7575.7, 122.10 to 1817.20 to 12.16 and 188.10 to 788.7 and the mean values in the range 1240, 501.7, 4.5 and 512.8 respectively. A critical study of Table 1 and Table 2 reveals that most of the parameters values were found significant and above the desirable limit (WHO, 1993) [25] in the samples throughout the study period. High maximum concentration of physico-chemical parameters may be due to percolation of industrial effluent into the ground water. The exceed values of these parameters cause many harmful effect [26-28]. A change in the physico-chemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water. For natural water bodies, the values for the general physico-chemical quality elements at high ecological status correspond totally to the values for the physico-chemical quality elements must remain within the ranges normally associated with undisturbed conditions. Therefore, physico-chemical parameters considers as ecological variables [29].

Table 1: Descriptive Statistic

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
pH	18	7.23	8.73	8.0244	.11363	.48209
Ca	18	17.60	379.50	78.7167	19.97883	84.76301
Mg	18	9.90	364.10	86.7167	19.79805	83.99602
Na	18	280.50	4623.30	936.5278	244.11983	1035.71274
K	18	3.85	29.70	11.1361	1.53908	6.52975
Cl	18	211.20	7575.70	1240.7000	410.42924	1741.30377
SO_4	18	122.10	1817.20	501.7667	124.93409	530.05047
NO_3	18	.06	12.16	4.5528	.80260	3.40514
HCO_3	18	188.10	788.70	512.8444	41.78614	177.28360
TDS	18	1139.60	15180.00	3376.5111	801.96133	3402.43375

Table 2: Physico-chemical Data and WQ

Sample	pH	Ca	Mg	Na	K	Cl	SO_4	NO_3	HCO_3	TDS	WQI
GW_1	8.0	91.3	25.3	280.5	4.95	370.7	258.5	3.63	188.1	1221	104.43
GW_2	7.83	379.5	364.1	4623.3	23.65	7575.7	1817.2	2.26	376.2	15180	1098.05
GW_3	8.55	132	166.1	2200	29.7	3231.8	1785.3	12.16	591.8	8140	624.9
GW_4	8.01	132.4	162.8	1265	12.65	1707.2	1182.5	5.08	380.6	4851	386.8
GW_5	7.81	144.1	82.5	506	9.9	856.9	512.6	2.2	211.2	2332	194.1
GW_6	8.69	50.6	35.2	561	6.05	726	393.8	5.87	550	2338.6	185
GW_7	8.73	28.6	9.9	352	4.4	211.2	122.1	10.12	492.8	1227.6	103.3
GW_8	8.60	31.9	30.8	280.9	5.35	225.5	122.5	8.69	436.7	1139.6	100.88
GW_9	8.5	37.4	22	429	3.85	399.3	207.9	2.97	430.1	1537.8	123
GW_{10}	8.67	37.8	33	473	9.35	443.3	244.2	8.58	521.4	1766.6	146.56
GW_{11}	7.97	38.5	77	660	11.55	689.7	162.8	1.32	731.5	2376	183
GW_{12}	7.69	52.8	112.2	907.5	11.95	1270.5	402.6	0.06	391.6	3157	242.1
GW_{13}	7.81	39.6	82.5	407	8.95	399.3	187	1.66	643.5	1777.6	144.98
GW_{14}	7.79	17.6	31.9	451	9.08	304.7	216.7	2.52	657.8	1694	130.45
GW_{15}	7.23	30.8	110	907.1	11	1016.4	411.4	5.73	646.8	3141.6	237.4
GW_{16}	7.57	44	106.7	1003.2	12.65	1089	341	5.19	786.5	3396.8	254.8
GW_{17}	7.67	40	26.4	396	14.02	435.6	216.7	2.36	405.9	1540	122.3
GW_{18}	7.32	88	82.5	1155	11.4	1379.4	447.7	1.55	788.7	3960	287.11
WHO	6.5-8.5	75	30	200	12	250	200	50	250	500	

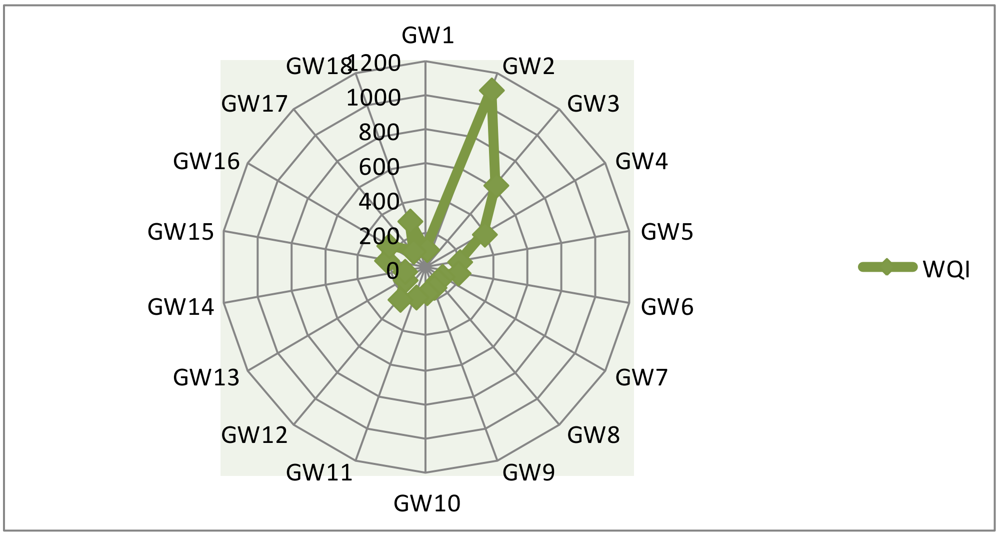
3.2. *Water Quality Indices*

Assembling different parameters into one single number leads an easy interpretation of water quality. It is inferred from the water quality ranges (100.88 to 1098.95), table 2, table 4 and figure 2 that higher percent of poor ground water. It is further inferred that the effective ionic leaching, overexploitation and anthropogenic activities such as discharge of untreated effluents from industries and domestic uses for such poor quality of ground water SITE area Karachi [30].

Table 4: WQI Range and Type of Water [32, 33]

Range	Type	Range	Type	Range	Type	Range	Type	Range	Type
< 50	Excellent	50-100	Good	100-200	Poor	200-300	Very poor	>300	Unsuitable

Figure 2: WQI Index Trends



3.3. *Correlation Coefficient for Physico-Chemical Parameters in Groundwater of Site Industrial Trading Estate*

The Pearson correlation analysis (Table 3) with respect to ten parameters, seven parameters namely Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}, Cl^{-1}, SO_4^{-2} *and TDS* show strong correlation among themselves. These strong positive relationships are an indication of common source. Correlation analysis reveals similarities or differences in the behaviour of not conveniently identify groups of ions that behave similarly [31].
The correlation co-efficient among WQI and these seven ecological variables demonstrated highly positive relationship (Table 5). It indicates the anthropogenic sources i.e Industrial effluent contributing towards contamination the groundwater in study area.

Table 3: Correlation Coefficient for Physico-chemical Parameters of Groundwater Samples

	pH	Ca	Mg	Na	K	Cl	SO_4	NO_3	HCO_3	TDS	WQI
pH	1										
Ca	-.112	1									
Mg	-.283	.886**	1								
Na	-.147	.906**	.955**	1							
K	-.178	.618**	.762**	.778**	1						
Cl	-.126	.933**	.952**	.996**	.760**	1					
SO_4	.004	.821**	.862**	.875**	.862**	.872**	1				
NO_3	.661**	-.116	-.111	-.008	.152	-.029	.213	1			
HCO_3	-.237	-.352	-.046	-.027	.126	-.104	-.140	.053	1		
TDS	-.131	.912**	.958**	.997**	.803**	.994**	.905**	.013	-.041	1	
WQI	-.114	.912**	.959**	.994**	.812**	.992**	.920**	.033	-.054	.999**	1

Table 5: Correlation Coefficient of Ecological Variables with WQI

Ecological Variables	Correlation Co-efficient with WQI	Ecological Variables	Correlation Co-efficient with WQI
pH	-0.114	Cl	0.992
Na	0.994	SO_4	0.920
K	0.812	NO_3	0.033
Ca	0.912	HCO_3	-0.054
Mg	0.959	TDS	0.999

Conclusion

The present study is limited to the groundwater contamination in Sindh industrial trading estate, Karachi, Pakistan. The results observed that most of physicochemical parameters shown higher values and calculated WQI for the groundwater samples range from 100.88 to 1098.95 and falls with poor to very poor class. Pearson correlation analysis identified anthropogenic contamination i.e. industrial, controlling the major process of groundwater chemistry. The results showed that groundwater in most of the sampling points are polluted & not healthy for human use without treatment. It is recommended that groundwater quality monitoring should be encouraged in order to ensure groundwater quality protection and conservation.

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