Sindh Univ. Res. Jour. (Sci. Ser.) Vol.50 (002) 227-234 (2018)

http://doi.org/10.26692/sujo/2018.06.0040

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Groundwater Quality Assessment Using Water Quality Index: A Case Study of Nagarparkar, Sindh, Pakistan

N. B. BHATTI, A. A. SIYAL*, A. L. QURESHI**

US-PCAS-W, Mehran University of Engineering and Technology (MUET), Jamshoro

Received 22nd February 2017 and Revised 05th March 2018

Abstract: In the present study, groundwater quality of hilly Nagarparkar area was assessed using water quality index (WQI). WQI was calculated based on the analysis of physicochemical parameters of groundwater viz. pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, total alkalinity (TA), total hardness (TH), chloride (Cl), dissolved oxygen(DO), sulphate (SO_4), calcium (Ca), magnesium (Mg), iron (Fe), cadmium(Cd), nickel (Ni), copper(Cu), manganese (Mn), arsenic (As) and fluoride (F). Groundwater samples were collected from the dug-wells of the study area, were preserved and analyzed by using standard lab methods. The analysis results of groundwater samples revealed that the physiochemical parameters, pH, Mg, fluoride, SO_4, Fe, Cu, Mn, Zn, and As in the groundwater were within the WHO permissible limit while rest of parameters exceeded the WHO permissible limit. Based on water quality index (WQI), the considered water quality parameters were found in various categories. Category wise, 20% of water samples had excellent, 15% good, 15% poor, 20% very poor water quality while the 30% of the samples were unsuitable for drinking purpose. Overall, the groundwater quality of most of the area was not suitable for drinking and domestic purposes

Keywords: Small Dams, Groundwater Quality, Water Quality Index, Physicochemical parameters

1. INTRODUCTION

Groundwater is a most important source of drinking water, which is used not only as a drinking purpose, but also for irrigation, livestock, industry, and domestic purposes. In fact, more than 2 billion people worldwide depend on groundwater for their daily use (Kemper 2003). Groundwater resources are vital in rural areas of arid zones which are still not connected to surface water supply network. Water pollution is one of the most severe environmental problems. Increasing stresses on groundwater supplies resulted in groundwater contamination issues in many parts of the world (Lugoli *et al.*, 2011; Guler *et al.* 2012; Huang *et al.*, 2013; Yolcubal *et al.*, 2016).

1. The population of Pakistan utilizes groundwater for drinking purpose is more than sixty percent. The people settled in rural areas of Pakistan, out of which 68% population having poor quality drinking water. According to GWSSAR (2000) reports, more than 3 million Pakistanis are suffered in various diseases due to the poor quality of water and out of which 0.1 million die annually (Bhatti *et al.*, 2006). In Pakistan, one hundred million cases of diarrheal diseases are being registered in hospitals within a year, and 0.25 million children die due to using of contaminated water. Contaminated water, purity, and hygiene practices are primary reasons of the diarrheal diseases, and around 0.25 million children die less than five years age annually. According to UNICEF, about 20-40% of the hospital beds in Pakistan were occupied by patients experiencing waterborne diseases, such as, typhoid, dysentery, cholera, and hepatitis, which are the reasons of 33% of all deaths (Solangi *et al.*, 2017). About 80% of all the diseases in human beings are caused by water (Dohare *et al.*, 2014). The accessibility of safe and affordable drinking water significantly affects the waterborne diseases.

WQI is an arithmetical tool used to transform large quantities of water quality data into a single cumulatively derived number. The Water Quality Index is one of the most effective tools to provide information on the quality of water to the concerned citizens andpolicymakers. It becomes an essential parameter for the assessment and management of groundwater. The WQI concept is related to the comparison of the water quality parameter with respective regulatory standards (WHO standards) and provides a single number thatexpresses overall water quality at a specific location based on several water quality parameters. The WQI summarizes a significant amount of water quality data into simple terms, i.e., excellent, good, bad, etc., which are easily understandable and usable by the public (AbbasiandAbbasi, 2012). However, by combining multiple parameters into a single index, a more comprehensive picture of the pollution state is provided.

Nagarparkar is the taluka of Tharparker district situated at the south-east corner of Sindh Province comes under arid zone and has annual rainfall rate less than 250 mm which not fulfill the growing need of settled communities. There is no any irrigation system, high temperature, wind erosion, sand dunes, uneven land; groundwater quality is saline and deep. Groundwater as the major available source of drinking water in this area and also rain is the source of groundwater recharge. Aquifers are directly relied on the rain even short drought leave adversely affect

++Corresponding Author: nabibuxbhatti76@gmail.com

on groundwater recharge. Water quality of its neighboring districts: (Thatta, Badin, and Thar) is also very poor and responsible for diarrhea, gastroenteritis, kidney, cholera and skin diseases (Memon *et al.*, 2011, Solangi *et al.*, 2017). The groundwater quality is severely affected by contaminants can be natural or human-induced and low precipitation. Inorganic chemicals that occur naturally in soils, sediments, and rocks. For example, dissolved mineral matter not only degrade the quality of groundwater but also affect the health and socio-economicdevelopment conditionsof the inhabitants (Reza and Singh, 2010).

2. MATERIALS AND METHODS

2.1. The Study Area

Nagarparkar was an ancient Hindu, and Jain pilgrimage site now is a town in Tharparkar District located at the south-east corner of Sindh Province of Pakistan and has a high potential for the harvesting of rainfall generated runoff from Karoonjhar hills. Nagarparkar is 129 km away from Mithi, located between latitude 24^0 14' N to 24^0 33' N and longitude 70^0 36' E to 71^0 03' and the cover area about 313.63 km^2. Annual average rainfall in Thar region varies from 4 to 6 inches, whereas in Nagarparkar occurs 13 to15 inches and more. The climatic condition of the study area is usually hot in summer; temperature ranges from 35^0 to 48^0 C and in winter between 3^0 to 15^0 C.

Nagarparkar area is divided into two categories on the basis of geomorphology, 1) Desert Nagarparkar 2) Hilly Nagarparkar. The desert covers the area of high sand dunes consisting of fine/coarse sand with silt. The drainage system of Thar is local, rainwater drain from sand dunes and accumulates into low-lying areas. The hilly (Nagarparkar) is mostly flat land than the desert, drainage system of hilly Nagar area is mainly developed, consisting of fifteen streams and rivers, locally called Nai. These seasonal Nai drain the rainwater from plain and Karonjhar hills to Ran Kutch. Further, hilly Nagarparkar also consists of mountains in which granite matter is available while desert Nagar consists of sand dunes. Granite Mountain covers the central part of the hilly Nagarparkar area and extends to approximately around 80 square kilometers. Elevated peak varies from 114 to 360 meters above the sea level. Karonjhar hills are mostly dark pink color but a few places light/medium gray color.

Karonjhar hills are surrounded with plains having steep slope varies from 6 to 12 meters per kilometers towards the coastal plain. Plains have been formed by the alluvium from the weathered material eroded from the Karonjhar hills. Old Status of water resources was boundon three types, which are Tarries (Natural ponds), water protection bunds and Dug well. In general groundwater quality of Nagarparkar region at the head and middle section of the Nai is little bit able to drink whereas the downstream quality of water is saline. Groundwater quality in plain little away from Nai/Nadis bed is mostly saline. There is no any irrigation system, and most deprived region need to make systematic efforts to assess groundwater quality, conserve water and utilize them properly. The studyis focused in only hilly Thar (Nangarparkar)

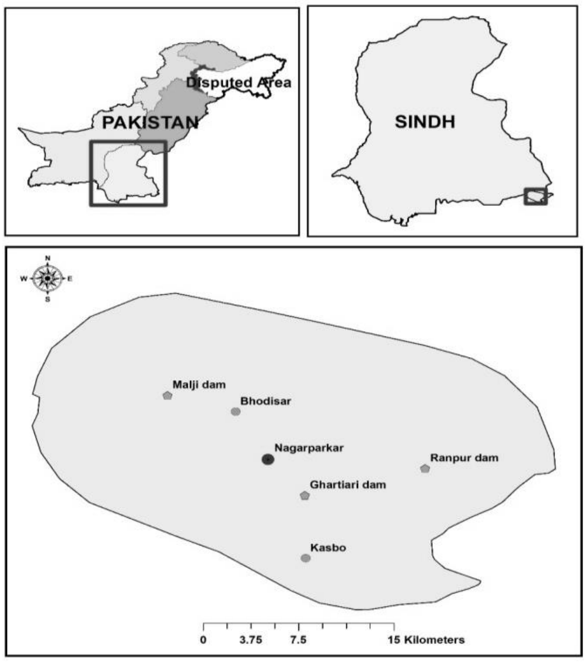

Fig. 1 Location map of study area

Sample Collection and Methods

A total of 29 water samples were collected from open wells of various villages of Hilly (Nagarparkar) area. These open wells were extensively used by the people for extracting groundwater for their domestic use. Groundwater sampling locations were located using the handheld Garmin GPS. Water samples have been collected in polythene bottles; the bottles were washed and rinsed properly with distilled water to remove any possible contamination. The collected samples were labeled correctly which indicates the source of the sample time and date of collection. The collected samples were brought to the laboratory and analyzed physical and chemical parameters according to WHO standards within the 48 hours of collection. Different physicochemical parameters of water samples were measured at the field and in the laboratory. Like pH, electrical conductivity (EC), salinity and total dissolved solids (TDS) were measured with Orion 420A pH meter and Orion 115 conductivity at the field. Total alkalinity (TA), total hardness (TH) and chloride(Cl) were determined by hydrochloric acid, titration with standard EDTA and silver nitrate respectively. Sulfate and fluoride(F) were determined by Hitachi 220 spectrophotometer, turbidity with turbidity meter, Calcium (Ca) and magnesium (Mg) calculated from hardness. Iron (Fe), cadmium(Cd), nickel (Ni), copper (Cu), manganese (Mn) and arsenic (As) were determined with Varian Spectra AA-20 atomic absorption spectrometer with standard burner head and air-acetylene flame and Merck Test Kit method respectively.

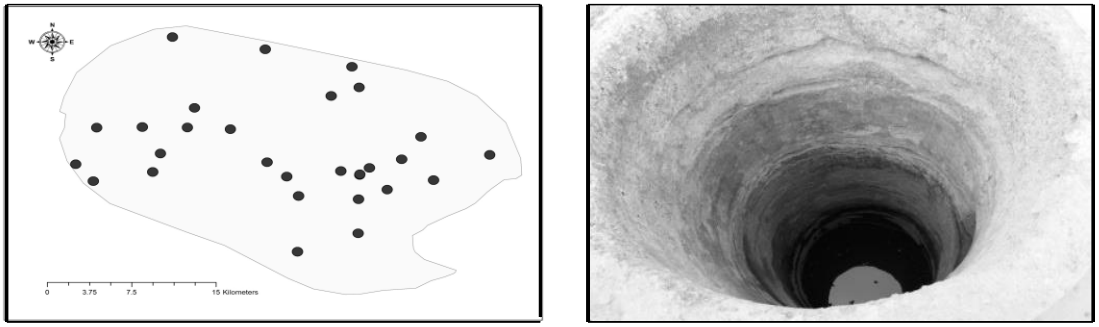

Fig. 2: Sampling Locations and their source

Tables. 1 The coordinate's summary of the water sampling sources and its depth.

SNO	Water sampling sources (Open well)			Depth (ft)	SNO	Water sampling sources (Open well)			Depth (ft)
	Villages	Sources coordinates				Villages	Sources coordinates		
		X	Y				X	Y	
1	Ranpur	70.86551 E	24.36776 N	50	16	Veekasar	70.60493 E	24.36309 N	25
2	Oan	70.67269 E	24.37331 N	60	17	Sukhpur	70.66641 E	24.35579 N	55
3	Naryasir	70.81696 E	24.35659 N	60	18	Bhodesar	70.72868 E	24.39623 N	60
4	Ghartiyari	70.78315 E	24.33309 N	35	19	Soora chand	70.83078 E	24.29763 N	50
5	Stay jo wandhio	70.7000 E	24.4164 N	40	20	Waadh Rai	70.75654E	24.47179 N	25
6	Kasbo	70.7822 E	24.28039 N	45	21	Kharero	70.65813 E	24.39825 N	35
7	Phulpro	70.936 E	24.372 N	42	22	Nagarparkar city	70.75795E	24.36494N	52
8	Kajy jo wandhio	70.832 E	24.353N	45	23	Koharo	70.891 E	24.348 N	60
9	Umedy jo wandhio	70.83974 E	24.35955 N	75	24	Bhamaro	70.854 E	24.339 N	60
10	Malji jo wandhio	70.69434 E	24.39783 N	45	25	Chitrasar	70.831 E	24.330 N	70
11	Sadhu Ras	70.80919E	24.42779N	70	26	Bako post	70.6218 E	24.39774 N	25
12	Asalari	70.881 E	24.389 N	50	27	Kaj jo wandhio	70.8322 E	24.3536 N	45
13	Mehron jo wandhio	70.77371 E	24.35143 N	50	28	Chanenda	70.82584 E	24.45525 N	42
14	Bandho	70.682270 E	24.48331N	60	29	Onher	70.6044 E	24.348 N	35
15	Danna Gaam	70.83158 E	24.43576 N	50	30				

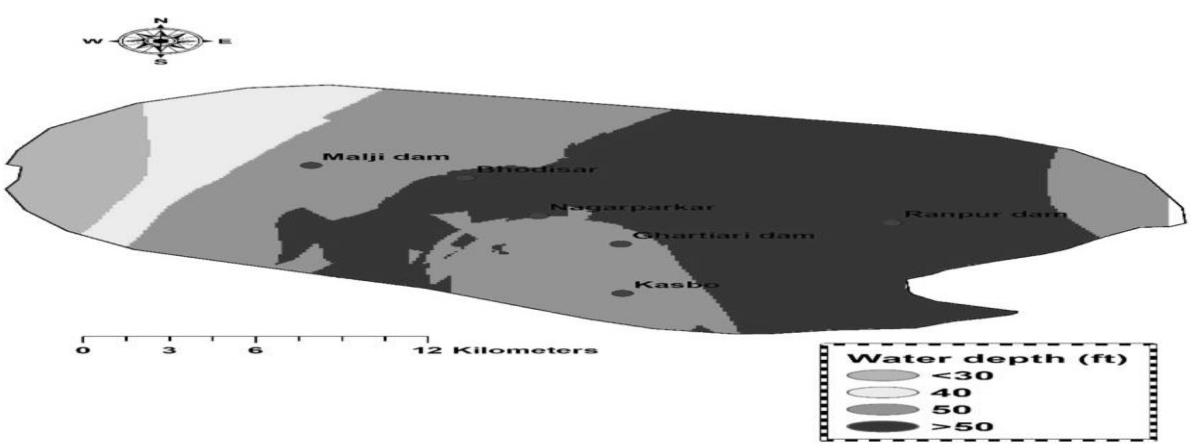

Fig. 3 Spatial variation in water table depth in the study area

Water Quality Index

In the present research study, total 20 Physiochemical parameters were selected for the calculation of water quality index according to WHO drinking water quality standard. For assessing the groundwater quality, water quality index has been used based on the parameters and calculated using the weighted arithmetic method. The concept of WQI first proposed by Horten (1965) and was developed by Brownetal (1970) and Cude (2001). WQI have been further developed and approved around the world (Prasad and Kumari, 2008; Reza and Singh, 2010; Manoj *et al.*, 2012; Dede *et al.*, 2013). Water quality classified into various categories according to (Shweta *et al.*, 2013).WQI depends upon the three equations which play very vital role in determining the index which is mentionedbelow.

The quality rating or **sub-index (qn)**was calculated using the following expression (Yogendra and Puttaiah, 2008):

$$qn = 100[V_n – V_0] / [S_n – V_0] \qquad (1)$$

Where**,**

qn issub-index, $\mathbf{V_n}$is the estimated value**, vi or** $\mathbf{v_0}$ is the ideal value and $\mathbf{S_n}$ is the standard value

Unit weight (W)

In this step, unit weight (Wi) was obtained using the following formula:

$$Wn = K/ Sn \qquad (2)$$

Wn = Unit weight of nth parameter**, K** is Constant for proportionality, and **Sn** is theStandard value of the nth parameter.

Total water quality index (WQI) calculated by the followingexpression.

$$WQI = \Sigma\ qnWn / \Sigma\ Wn \qquad (3)$$

The ideal value of all the physiochemical parameters counted as zero whereas pH and dissolved oxygen values counted 7 and 14.6 mg/l respectively (Tripathy and Sahu, 2005; Chowdhury *et al.*, 2012).

3. RESULTS AND DISCUSSIONS

In the present research study, total 29 groundwater samples were collected from open wells of various villages. At least one samplewas taken from each village were analyzed for assessing groundwater quality. Results obtained after analyzing were mentioned in Table 2 consists of the observed values of the parameters along with units, standard limit given by WHO and overall observed result summary of the Physiochemical Parameters. Overall observed result summary of the parameters classified the positions of the said parameters according to three categories such as (less the WHO limit, within WHO limit and exceed the WHO limit. Details of the number of the parameters discussed according to categories in percentage. Normal statistical analysis of the 20 parameters given in table.3. Statistical analysis of each parameter done based on the maximum, minimum and average results, details of eachparameter mentioned in the same table. Groundwater quality assessed based on the physiochemical parameters by using water quality index (WQI). Water quality index calculated using the weighted arithmetic method, detail of the water quality index for each parameter mentioned in Table.4 and Fig.4, while water quality classified based on the water quality.

The overall results revealed that the majority of physiochemical parameters about 65% over the WHO standard permissible limit and 35% within the WHO limit. Water quality index status of eachparameterwas found in various categories such as excellent, good, poor, very poor and unsuitable for drinking purpose. Status of the observed results and water quality index of each parameter discussed below in detail.

In present research study, **pH** ranged were varying between 7.02 – 8.9, 96 % result of the samples within WHO standard limit, 4% exceed the WHO standard permissible limit and WQI result calculated 164 which come under poor category according to water quality classification.

Most of the **Electrical conductivity EC** results were found exceed the WHO standard permissible limit, out of which 17 % values of the samples within the WHO standard limit, 83% exceed the WHO standardlimit and WQI was found 352 which is unsuitable for drinking purpose according to water quality classification.

Regarding the result of **TDS,** 30.6 % of the samples are within the WHO standard limit, 69.4 % exceeds the WHO permissible limit, and the result of the WQI found 264.5 which comes under very poor category according to water quality classification. Water containing more than 1000 mg/L of TDS is not palatable as drinking water.

Turbidity ranged between 0.69-36.5, 58 % values of the samples within the WHO standard limit, 42% exceed the WHO permissible limit, and the result of WQI found 107.1 which comes under poor category according to water quality classification.

Alkalinity values were varying between 40 – 200, 28% result of the samples within the WHO standard, 72% exceed the WHO standard limit, and the result of the WQI found 234 which comes under very poor category according to water quality classification.

Total hardness result was varying from 120 – 4000, 58% values of the samples within the standard limit, 42% exceed the WHO standard limit and the average result of the WQI found 250 which comes under very poor category according to water quality classification.

Chloride values were between the ranged 50 – 4000, 56% values of the samples within the WHO limit, 44% exceed the WHO permissible limit, and the result of the WQI found 455 which is unsuitable for drinking purpose according to water quality classification.

DO values were varying from 4.6 – 6, 38 % values of the samples within the WHO standard limit, 62 % exceed the WHO standard limit and the average result of the WQI found 95.8 which comes under good category according to water quality classification.

Sulphate values were ranged between 4.69 – 222.15, 100% values of the samples within the standard limit and WQI was found 42.5 which come under excellent category according to water quality classification.

Calcium values varying from 40 – 1600, 54% values of the samples within the standard limit, 46% exceed the WHO standard limit, and the result of the WQI found 407.85 which is unsuitable for drinking purpose according to water quality classification.

Magnesium result varying from14.4 – 434.88, 65% values of the sample within the WHO standard limit, 35% exceed the WHO permissible limit and result of the WQI was found 184.5 which comes under poor category according to water quality classification. Iron ranged varying from 0.08 **-** .3642, 100% values of the samples within the WHO standard limit, and the result of the WQI was found 54.65 which comes under good category according to water quality classification.

Cadmium values varying from 0.0216 **-** 0.1662, 100% values of the samples above the WHO standard permissible limit and result of the WQI also found 790 which is unsuitable for drinking purpose according to water quality classification.

Lead results ranged amid 0.022 – 0.1891, 10% values of the sample within the standard limit, 90% exceed the WHO standard limit, and the average result of the WQI found 204 which comes under very poor category according to water quality classification.

Nickel result ranged amid 0.072 – 0.1892, 100% values of the all samples exceed the WHO permissible limit and result of the WQI found 835 which is unsuitable for drinking purpose according to water quality classification.

Copper values varying from 0.023 – 0.2913, 100% values of samples within the WHO limit and average result of the WQI found 7.98 which is excellent for drinking purpose according to water quality classification.

Manganese result found varying from 0.007**-** 0.132, 96% values of samples within the WHO limit, 4% exceed the WHO permissible limit and average result of the WQI found 63 which comes under good category according to water quality classification.

Zinc result found varying from 0.111 – 0.5391, 100% values of samples within the WHO limit and result of the WQI found 1.81 which is excellent for drinking purpose according to water quality class**Arsenic** 0 – 0.025, arsenic appeared in 4% samples within WHO limit and 96% samples were free from arsenic and result of the WQI found 4 which is excellent for drinking purpose according to water quality classification.

Fluoride result varying from 0.69 – 1.336, average result of the fluoride was found in the sample within the WHO standard limit, and the result of the WQI found 76.75 which is good for drinking purpose according to water quality classification.

Tables 2: Observed Values, WHO Standard limit range and Observed result Summary of the Physiochemical Parameters

Location	Physiochemical Parameters																			
	Ph	EC	TDS	TUR	ALK	TH	CL	DO	SO4	Ca	Mg	Fe	Cd	Pb	Ni	Cu	Mn	Zn	As	Floride
UNITS		ms/cm	mg/ L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	WHO STANDARD LIMIT																			
	6.5-8.5	1.5	1000	5	200	300	250	5	250	75	50	0.3	0.01	0.05	0.02	1.5	0.1	15	0.05	1.5
	OBSERVED VALUES																			
1	7.45	1.36	670	1.74	355	200	155	5.6	53.9	80	28.8	0.1321	0.0321	0.0691	0.0881	0.161	0.0081	0.321	0	0.93
2	7.52	1.96	1000	1.04	245	400	450	5.8	138.82	160	57.6	0.1613	0.0216	0.0321	0.0921	0.0881	0.0776	0.3101	0	1.138
3	7.5	5.45	2710	7.48	270	720	725	5.4	198.34	288	103.68	0.0811	0.0361	0.161	0.0561	0.023	0.0431	0.2321	0	1.46
4	7.2	1.56	770	23.1	260	120	235	5.2	213.42	48	17.28	0.2412	0.0589	0.1201	0.1891	0.1921	0.0099	0.4316	0	1.024
5	7.98	1	1000	4.76	380	4000	1450	4.8	66.6	1600	57.6	0.0393	0.0333	0.0516	0.1121	0.2901	0.0087	0.1629	0.005	1.292
6	8.03	5.95	3020	1.01	1500	760	1250	5	174.53	304	109.44	0.1671	0.0232	0.0221	0.1612	0.0821	0.0132	0.5391	0	1.054
7	7.8	1.5	740	10.3	230	200	350	5.2	42.79	80	28.8	0.0891	0.1132	0.0891	0.0992	0.0391	0.0169	0.2216	0	0.599
8	7.58	19.68	9660	21.8	2000	1700	850	4.6	219.77	680	244.8	0.192	0.1321	0.111	0.0819	0.0562	0.0269	0.3091	0.025	0.747
9	7.95	15.51	7670	35.6	1500	1380	1050	5	222.15	552	198.72	0.2318	0.1432	0.121	0.112	0.1671	0.0112	0.1691	0.01	1.133
10	8.25	4.78	2390	1.99	1000	380	350	5.4	180.88	152	54.72	0.3642	0.0891	0.0721	0.0992	0.0766	0.132	0.2162	0	1.163
11	8.91	3.04	1520	1.69	1000	180	1200	5.4	114.61	72	25.92	0.0722	0.0823	0.052	0.101	0.0447	0.0619	0.1819	0.005	1.44
12	8.48	2.34	1170	1.7	385	160	850	4.6	59.46	64	23.04	0.0561	0.0391	0.0671	0.231	0.0883	0.0722	0.4304	0	1.009
13	8.01	3.09	1540	4.38	395	260	1100	6	124.53	104	37.44	0.08	0.0562	0.0891	0.161	0.1631	0.0076	0.3912	0	0.891
14	7.38	6.47	3300	36.5	805	160	1600	4.6	158.66	64	23.04	0.1625	0.0491	0.091	0.0352	0.232	0.0112	0.111	0.005	1.336
15	7.33	1.72	860	1.48	190	200	300	5.6	133.11	80	28.8	0.1592	0.1111	0.202	0.0231	0.2913	0.0212	0.262	0	1.336
16	7.3	7.7	3980	10.02	355	1060	400	4.6	187.71	424	152.64	0.182	0.1662	0.1061	0.0561	0.0996	0.0191	0.1192	0.002	
17	8.43	2.08	1040	21.9	220	160	350	6	30.09	64	23.04	0.0911	0.0626	0.022	0.891	0.0761	0.0923	0.202	0	1.24
18	7.6	3.21	1600	1.73	380	440	700	5	18.190	176	63.36	0.2311	0.0462	0.0916	0.0463	0.1722	0.0773	0.5391	0	1.16
19	8.35	3.2	1540	1.65	60	100	500	5	47.55	40	14.4	0.2891	0.0719	0.0491	0.1391	0.196	0.891	0.5001	0.001	1.29
20	7.54	19.9	10070	9.02	200	2120	2850	5.2	152.31	848	305.28	0.222	0.0701	0.0981	0.1203	0.231	0.0088	0.162	0.002	0.69
21	8.04	2.29	1140	6.43	400	240	550	5.2	18.98	96	34.56	0.261	0.1321	0.162	0.1612	0.081	0.0191	0.1891	0	1.3
22	7.74	3.46	1820	0.69	260	520	700	5.6	36.44	208	74.88	0.1628	0.1231	0.2042	0.0881	0.0716	0.0201	0.392	0	1.2
23	8.02	5.4	2500	1.13	360	320	1150	5	53.11	128	46.08	0.0348	0.0992	0.0619	0.0188	0.0348	0.0319	0.4201	0	1.44
24	7.78	6.14	3060	5.43	200	780	1350	5	60.25	312	112.32	0.0591	0.0399	0.082	0.072	0.0467	0.0519	0.222	0	1.04
25	7.83	1.98	1000	0.91	60	500	3450	5.4	211.04	200	72	0.2601	0.1621	0.1891	0.1612	0.1912	0.0553	0.1911	0	1.42
26	7.7	14.4	7200	9.57	80	1800	3750	5.2	95.96	720	259.2	0.1891	0.1821	0.261	0.0982	0.131	0.0626	0.2991	0.005	1.28
27	8.55	5.16	2400	1.82	320	200	1300	5.2	53.11	80	28.8	0.081	0.1132	0.0891	0.0991	0.0392	0.0169	0.2216	0	1.48
28	8.06	0.79	340	1.4	40	120	50	5.2	4.69	48	17.28	0.2413	0.0588	0.1202	0.1892	0.1922	0.0099	0.4316	0	0.98
29	7.02	2.01	1000	0.72	200	3020	4000	5.6	107.87	1208	434.88	0.226	0.0709	0.0991	0.1208	0.235	0.0089	0.165	0	1.33

Observed Results Summary of the Physiochemical parameters in percentage (%)

Parameters	pH	EC	TDS	TUR	ALK	TH	CL	DO	SO4	Ca	Mg	Fe	Cd	Pb	Ni	Cu	Mn	Zn	As	Fluoride
Within WHO Limit	96	17	30.6	58	28	58	56	38	100	54	65	100	0	10	0	100	96	100	100	100
Exceed WHO limit	4	83	69.4	42	72	42	44	62	0	46	35	0	100	90	100	0	4	0	0	0

Table. 3: Normal statistical analysis of groundwater quality parameters

SNO	Parameters	Maximum	Minimum	Average	SNO	Parameters	Maximum	Minimum	Average
1	pH	8.91	7.02	7.82	11	Mg	434.88	14.4	92.35
2	EC	19.9	0.79	5.28	12	Fe	0.3642	0.08	0.164
3	TDS	10070	340	2645	13	Cd	0.1662	0.0216	0.079
4	TURBIDITY	36.5	0.69	5.355	14	Pb	0.1891	0.022	0.102
5	ALK	2000	40	470	15	Ni	0.1892	0.072	0.167
6	TH	4000	120	751.03	16	Cu	0.2913	0.023	0.120
7	CL	4000	50	1138.44	17	Mn	0.132	0.0076	0.063
8	DO	6	4.6	5.4	18	Zn	0.5391	0.111	0.287
9	SO_4	222.15	4.69	109.61	19	As	0.025	0	0.002
10	Ca	1600	40	306.20	20	Floride	1.336	0.69	1.15

Table.4 Calculation of water quality index

Parameters	**Observed valuesvn**	**Ideal value Vi / v0**	**Standard valuesSn**	**Unit Weight (Wn)**	**Quality Index(Qn)**	**Wn Qn**	**Water Quality index (WQI)**
Ph	7.82	7	7.5	0.133	164	21.81	**164**
EC	5.28	0	1.5	0.666	352	234.43	**352**
TDS	2645	0	1000	0.001	264.5	0.2645	**264.5**
TURBIDITY	5.355	0	5	0.2	107.1	21.42	**107.1**
ALK	470	0	200	0.005	235	1.17	**234**
TH	751.03	0	300	0.003	250.34	0.75	**250**
CL	1138.44	0	250	0.004	455.37	1.828	**455**
DO	5.4	14.6	5	0.2	95.83	19.16	**95.8**
SO_4	109.61	0	250	0.004	43.84	0.17	**42.5**
Ca	306.20	0	75	0.014	408.26	5.71	**407.85**
Mg	92.35	0	50	0.02	184.7	3.69	**184.5**
Fe	0.164	0	0.3	3.33	54.66	182.01	**54.65**
Cd	0.079	0	0.01	100	790	79000	**790**
Pb	0.102	0	0.05	20	204	4080	**204**
Ni	0.167	0	0.02	50	835	41750	**835**
Cu	0.120	0	1.5	0.666	8	5.32	**7.98**
Mn	0.063	0	0.1	10	63	630	**63**
Zn	0.287	0	15	0.066	1.91	0.12	**1.81**
As	0.002	0	0.05	20	4	80	**4**
Floride	1.15	0	1.5	0.666	76.66	51.05	**76.65**
Average Water Quality Index (Av: WQI)							**229.71**

4. CONCLUSION

In present research study, 29 twenty-nine groundwater samples were collected from open wells of various villages and analyzed at a lab. The analysis results revealed that 30% of the groundwater samples are above the maximum permissible limits prescribed by WHO and unsuitable for drinking purpose, 20% of the samples are very poor quality, 15% % of the samples are poorquality, and 35%of the samples are suitable for drinking purpose. Groundwater quality assessed based on physiochemical parameters by using water quality index (WQI). The WQI of the mentioned parameters such as pH, EC, TDS, Turbidity, Alkalinity, TH, CL, DO, SO_4, Ca, Mg, Fe, Cd, Pb, Ni, Cu, Mn, Zn, As and Fluoride were determined and found in various categories such as excellent, good, poor, very poor and unsuitable for drinking purpose.Category wise detail of the each parameters such as (As, Cu, So_4, and Zn), (DO, Fluoride, Fe, and Mn), (Mg, pH, Turbidity and TDS), (Alk, Pb and TH) and (Ca, Cd, Cl, EC, and Ni) were found in excellent 20%, good 15%, poor 15%, very poor 20% and 30% of the samples unsuitable for drinking purpose respectively.The overall average result of the WQI was found in a very poor category which affects the health and socio-economic conditions of the inhabitants. The higher the concentrations of physiochemical parameters and metals in groundwater may cause diseases like diarrhea, dysentery, worm infestation, skin diseases, gall, renal stones, along with various ulcers and water-borne diseases. These mentioned diseases were also common among the peoples of such area. In the studyarea, water qualities of drinking water sources were not suitable for drinking purpose as well as domestic purpose. Awareness may bebrought into public not to use the water of such quality, highest priority should be given to water quality monitoring, and the indigenous technologies should be adopted to make water fit for drinking purpose.

REFERENCES:

Abbasi, T., S. A. Abbasi, (2012). "Water quality indices." Elsevier, Amsterdam, Netherlands, 384Pp.

Brown, R. M., N. I. McClelland, R. A. Deininger, R. G. Tozer, (1970). "Water quality index-do we dare? Water Sewage Works Vol. 117 (10), 339–343. http://www.sciepub.com/reference/14011.

Chowdhury, R. M., S. Y. Muntasir, H. M. Monowar, (2012). Water Quality Index of Water Bodies Along Faridpur-Barisal Road in Bangladesh, Global Eng. Technol. Rev.Vol. 2 (3). 456-462.

Dede, O. T., M. M.Telci, (2013). The Use of Water Quality Index Models for the Evaluation of Surface Water Quality: A Case Study for Kirmir Basin, Ankara, Turkey. Water Qual. Expo Health. Vol. 5, 41–56.

Deepa N.B., (2014).Water Quality Assessment In Terms Of Water Quality Index, Global General of Biology, Agriculture and Health Sciences, 3 (3), 69-71.

Dohare, D., and A. Kotiya, (2014). "Analysis of Ground Water Quality Parameters", Research Journal of Engineering Sciences, Vol. 3 (5), 26-31.

Ewaid, S. H., (2016). Water Quality Evaluation of Al-Gharraf River South of Iraq by Two Water Quality Indices, Springer. Appl. Water. Sci. http://dx.doi.org/10.1007/ s13201-016-0523-z.

Ewaid, S. H., and S. A. Abed, (2017). "Water quality index for Al-Gharraf River, southern Iraq", Egyptian Journal of Aquatic Research, Vol. 43, .117-122.

Ewaid, S. H., (2016). Water Quality Assessment of Al – Gharraf River, South of Iraq by the Canadian Water Quality Index (CCME WQI). Iraqi J. Sci. Vol. 57 (2A), 878–885.

Guler C., M A. Kurt M. Alpaslan, C. Akbulut (2012). Assessment of the impact of anthropogenic activities on the groundwater hydrology and chemistry in Tarsus coastal plain (Mersin, SE Turkey) using fuzzy clustering, ultivariate statistics, and GIS techniques. J Hydrol Vol. 414, 435–451.

Haq, A., H. Afridi, F. Amin, and A. Khan, (2015). Evaluation of Drinking Water Quality in Rural Areas of Khyber Pakhtunkhwa Pakistan: A Case Study of Upper Dir and Barawal Districts, International Journal of Current Engineering and Technology, Vol. 5, No.1, . 389-396.

Horton, R. K.., (1965)."An index number system for rating water quality", J. Walter Poll. Cont. Fed. Vol. 37 (3), .300–306.

Huang G X., J. C. Sun Y. Zhang, Z. Y. Chen, F Liu (2013). Impact of anthropogenic and natural processes on the evolution of groundwater chemistry in a rapidly urbanized coastal area, South China. Sci Total Environ 463:209–221. doi:10.1016/j. scitotenv.2013.05.078.

Kemper K. E (2003). Groundwater from development to management. Hydrogeol J Vol. 12(1), 3–5. doi:10.1007/s10040-003-0305-1.

Lugoli F, M. I. Leopizzi, F. Bagordo. De Donno (2011). Widespread microbiological groundwater contamination in the South-eastern Salento (Puglia-Italy). J Environ Monit 13(1),.192–200. doi:10.1039/c0em00193g.

Manoj, K., P. Kumar, S. Chaudhury, (2012). "Study of heavy metal contamination of the river water through index analysis approach and environ metrics". Bull. Environ. Pharmacol. Life Sci. Vol.1 (10), 7–15.

Sharma, P. K., R. Vijay, M. P. Punia (2016). "Groundwater Quality Assessment Using Water Quality Index And Gis In Rajasthan, India, International Journal of Advancement in Remote Sensing, GIS and Geography, Vol.4, No.2, . 12-26.

Shweta, T., S. Bhavtosh, S. Prashant, D. Rajendra, (2013). Water quality assessment in terms of water quality index. Am. J. Water Res. Vol. 1 (3), 34–38.

Solangi, G. S., M. M Siyal, and P Siyal (2017). Groundwater Quality Mapping using Geographic Information System: A Case Study of District Thatta, Mehran University Research Journal of E,ngineering and Technology, Vol. 36(4), 1059- 1072.

Tripaty, J. K., K. C. Sahu. (2005). Seasonal hydrochemistry of groundwater in the barrier spit system of the Chilika Lagoon, India. J. Environ. Hydro. Vol. 13, 1–9.

Yogendra, K., and E. T. Putaiah, (2007)."Determination Of Water Quality Index And Suitability Of an Urban Water body In Shimoga Town, Karnataka", The 12th World Lake Conference, .342-346, Proceeding of Taal.