Pak. J. Chem. 5(3): 138-145, 2015
ISSN (Print): 2220-2625
ISSN (Online): 2222-307X
Full Paper
DOI: 10.15228/2015.v05.i03.p06

Assessment of Ground Water Quality at Selected Locations Inside Karachi City

[*]S. M. S. Nadeem, S. Masood, B. Bano, Z. A. Pirzada[a], M. Ali
[*]Department of Chemistry, University of Karachi, Pakistan.
[a]Department of Microbiology, University of Karachi, Pakistan.
E-mail: [*]saqib.chemist@gmail.com

ABSTRACT
The physico-chemical and microbiological water quality parameters of ground water samples from different locations inside Gulshan-e-Iqbal Town, Karachi were analyzed by standard methods of analysis. The drinking water quality parameters such as pH, Total Dissolved Solids (TDS), Electrical conductance (EC) and concentration of important minerals such as Calcium (Ca^{2+}) Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), and Sulphate (SO_4^{2-}) in ground water samples was determined and the experimental values were compared with the World Health Organization (WHO) and Pakistan Standard and Quality Control Authority (PSQCA) standards to evaluate the feasibility of ground water samples to be used as drinking water. The physico-chemical parameters of 90% ground water samples were found to be in compliance with WHO and PSQCA drinking water quality standards whereas microbiological characteristics of 70% of ground water samples were found satisfactory enough to permit there use as potable water.

Keywords: Gulshan-e-Iqbal; WHO; PSQCA; Total Dissolved Solids; Physico-chemical

1. INTRODUCTION
Ground water is that water which perforates through the layers of soil and saturates the underground rocks and sediments. Ground water is one of our most vital natural resources as it can serve as a source of drinking water, for irrigation of crops and as domestic water for household use. In rural areas of different countries, underground water is the most commonly used source of drinking water[1-2]. The concentration of different important minerals, heavy metals and toxic chemicals in groundwater can play an important role in our health if it is used for drinking purpose[3]. The chemical constitution and quality of the ground water is influenced by several factors such as chemical weathering of rocks, dumping of industrial wastage and rains[4]. It is supposed that the ground water is much cleaner than land water but as the ground water lies below the earth surface and out of sight, various chemicals spilled or dumped on the ground's surface or leaked from septic systems can infiltrate into the ground and may end up in the ground water[5]. Furthermore, the quality of ground water reservoirs is also affected by the increase in population and associated domestic activities[6-8]. Once pollutants enter ground water they can be difficult to detect by taste or smell, and difficult to remove and they may then end up in ground water used for drinking and irrigation however the ground water is usually biologically more satisfactory than fresh water because the perforation of water through the layers of soil filters out a significant proportion of microbial contamination. To continuously monitor the hydrochemistry of rivers and surface water reservoirs, long term and sustainable quality analysis programs are mandatory[9-10].

The importance of the chemical assessment of ground water underlies the fact that the chemistry of ground water can directly be related with the source of water, climate, and geology of the region. For our study, Gulshan-e-Iqbal Town of Karachi City was selected and ground water samples from different locations were analyzed. The main aim of this study is to develop a clear picture about the chemical composition and type of microorganisms present in ground water and to determine feasibility for its use as drinking water. The concentration of different cations and anions in ground water will be compared with the WHO and PSQCA guidelines for drinking water.

2. MATERIALS AND METHODS
2.1 *Chemicals and Glassware*
All the glasswares of Pyrex (IsoLab-Germany) were used while all the chemicals of analytical reagent grade purchased from E-Merck were used for quantitative analysis. The different chemicals used in the physic-chemical analysis of water samples are ethylenediammine tetra acetic acid (EDTA), silver nitrate ($AgNO_3$), sodium hydroxide (NaOH), liquor ammonia (NH_4OH), ammonium chloride (NH_4Cl), potassium chromate (K_2CrO_4), Barium Chloride ($BaCl_2$), sodium chloride (NaCl), potassium chloride (KCl), hydrochloric acid (HCl), erichrome black T, calcon, methyl orange, phenolphthalein while plate count agar (Merck) and MacConkey agar (Oxoid) were used for microbiological analysis of water samples. All the analytical reagents and microbiological media were prepared in double distilled water having conductance of 6.0×10^{-2} $\mu S.cm^{-1}$.

2.2 *Collection of Ground Water Samples*
The geographical map of Karachi is shown in Figure-1. Ground water samples were collected from 10 boreholes at different locations inside Gulshan-e-Iqbal Town of Karachi city on 25th May 2013. The sampling plan is shown in Table-1. All these sources of sample collection were used for drinking and domestic purpose by the residents of the

*Corresponding Author
Received 27th January 2015, Accepted 10th February 2015

area. Polythene bottles (1.0 dm^3) were used for sampling of ground water. The bottles were rinsed first with distilled water, rinsed a further two or three times with the water being sampled, and then the water samples were taken.

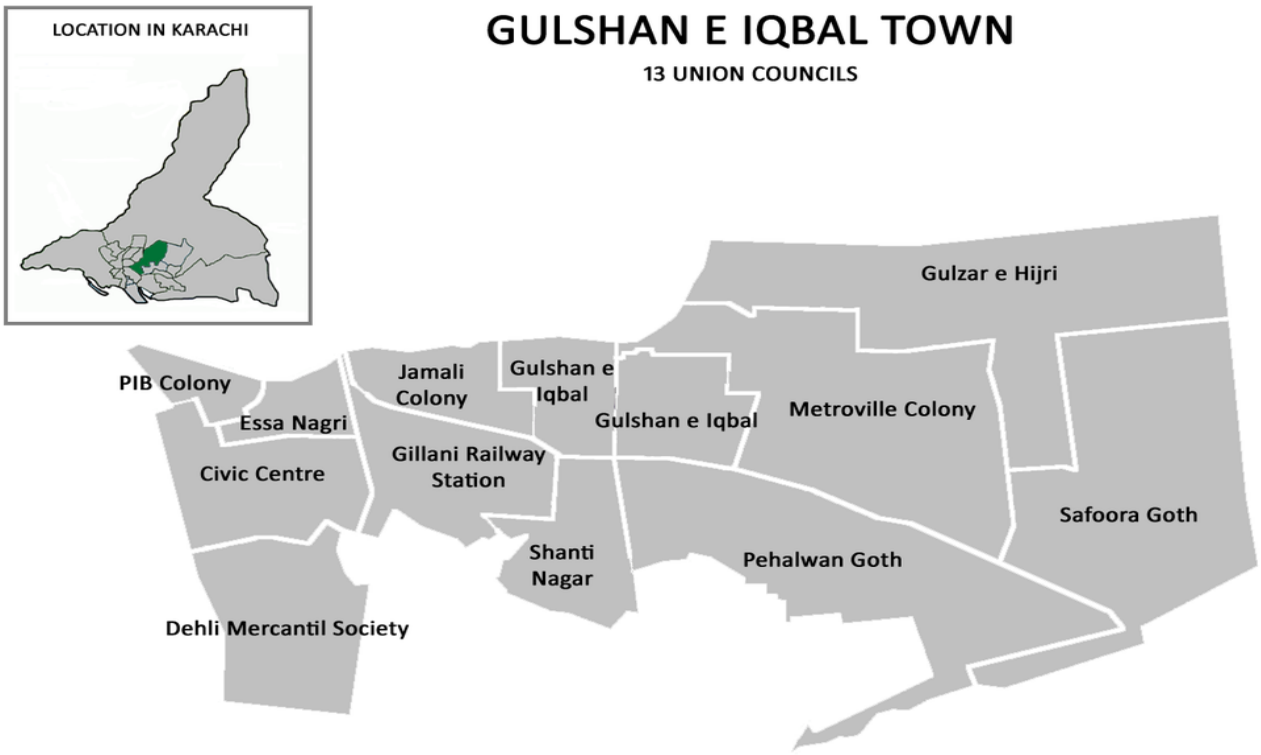

Fig.1: The Geographical Map of Gulshan-e-Iqbal Town, Karachi

Table-1: Water Sampling Plan

Sample No.	Sample	Type of Sample
01	Gulshan-e-Iqbal Block 2 (Home)	Tap Water
02	Opposite Aladdin Park (Home)	Tap Water
03	Sohrab Goth (Home)	Tap Water
04	National stadium	Tap Water
05	Hasan Square (Home)	Tap Water
06	PCSIR	Tap Water
07	Federal Urdu University	Tap Water
08	Nipa Chworangi (Home)	Tap Water
09	Bait-ul-Mukharram Mosque	Tap Water
10	Bahadurabad	Tap Water

3. METHODOLOG

3.1 *Physico-chemical Analysis*

The water samples were analyzed in triplicate. The classical as well as instrumental methods of analysis were used for the analysis of water samples. The TDS, pH and electrical conductivity was determined by combine glass electrodes. The Ca^{2+} and Mg^{2+} were determined by complexometric titration while Cl^- was determined by precipitation titration. The alkali metal ions Na^+ and K^+ were analyzed by flame photometry while SO_4^{2-} was determined by turbidimetric analysis.

3.2 *Microbiological Examination*

Total viable plate count (TVPC) was performed by pour plate technique. Water samples were diluted and plated on R2A media (Merck) and MacConkey agar plates (Oxoid) and incubated at 37^{o}C for 48 hours. For TVPC, water samples were diluted in a ratio of 1:100 dilution while for pathogenic bacteria (E coli and P aeruginosa) 1:10 dilutions were prepared. For TVPC test, 1 mL of water sample was inoculated on plate count agar medium in petri plates while for the detection of *Escherichia coli* and *Pseudomonas aeruginosa* 250 mL of water sample was filtered through a filtration assembly and the filter paper was inoculated on MacConkey agar plates. After incubation colonies were counted and plates were checked for the presence of *Escherichia coli* as the indicator of coliform and *Pseudomonas aeruginosa* by routine diagnostic tests.

3.3 *Statistical Analysis*

The variation in magnitude of different drinking water quality parameters of ground water samples from Gulshan-e-Iqbal Town was determined by calculating standard deviation of the results.

4. RESULTS AND DISCUSSION

4.1 *Physico-Chemical Analysis*

The different physic-chemical water quality parameters analyzed are tabulated in Table-2 and the experimental values are compared with the WHO and PSQCA guidelines. The variation in concentration of different cations and anions is represented by the bar graphical representation.

pH

The pH is a fundamental drinking water quality parameter. The pH of drinking water must be within a suitable range. In our study, the pH of water samples was in the range of 7.3 to 7.7 which is within WHO and PSQCA standards of 6.5 to 8.5. The WHO and PSQCA standards are based on the fact that the acidic water becomes corrosive in nature while the basic water develops a rather bitter taste. A water sample that satisfies other drinking water quality parameters as per WHO and PSQCA standards tastes best at a pH of 7.5 ± 0.1. Also, a shift in pH of water towards alkaline side may even bring about biologically harmfull transformations in chemical composition of water e.g., ammonium ions may convert into highly toxic ammonia molecule with a rise in pH[11]. The variation in pH of water samples is shown in Figure-2.

Table-2: Physico-Chemical Water Quality Parameters of Ground Water in Different Areas of Gulshan-e-Iqbal Town

Sample No.	pH	*K* (µS)	TDS	TA	Na^+	K^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	Cl^-
01	7.62	1183	651	157	40	10	45	20	100	80
02	7.33	855	440	140	25	5	81	10	150	50
03	7.63	818	426	134	30	8.4	50	15	90	90
04	7.45	838	431	115	45	8.1	55	15	50	100
05	7.59	985	502	105	40	7.7	47	17	80	115
06	7.48	1001	521	96	48	8.2	60	16	45	85
07	7.68	986	478	100	54	10.5	65	19	115	68
08	7.55	866	473	95	46	9.8	91	15	105	168
09	7.67	889	464	89	39	10	39	10	54	74
10	7.56	1085	535	103	37	9	40	24	60	93
WHO	6.5 – 8.5	1400	1000	120	200	-	100	150	250	250
PSQCA	6.5 – 8.5	-	500	-	50	10	100	50	250	250
STD	**0.109**	**122.43**	**69.28**	**22.68**	**8.527**	**1.610**	**17.37**	**4.280**	**33.68**	**32.03**

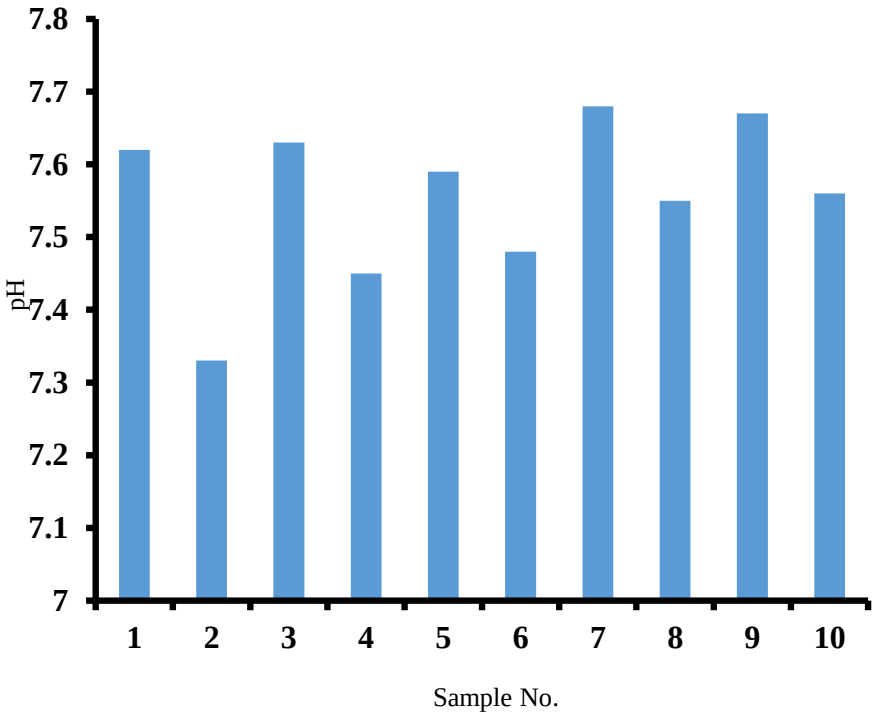

Fig.2: The pH variation of water samples from different locations inside Gulshan-e-Iqbal Town

4.2 *Conductance*

The conductance of water is due to cations and anions of dissolved salts. The conductance of a water sample is indirectly related to its TDS. The WHO emphasizes that the conductance of drinking water does not exceed 1400 µS. In our study, all the samples from Gulshan-e-Iqbal Town complied with the WHO and PSQCA standards in terms of conductance.

4.3 *Total Dissolved Solids (TDS)*

The TDS is directly related to the salinity of water and indicates the quantity of dissolved inorganic salts in water. Some organic species of ionic nature also contribute to the TDS. The WHO recommends that the TDS of drinking water must not exceed 1000 $mg.L^{-1}$ while PSQCA standards suggest that only water with TDS of less than 500 $mg.L^{-1}$ is suitable for drinking. In our analysis, all the samples complied with the WHO standards while nine samples complied with the PSQCA standards. One sample had a higher TDS than permissible by PSQCA standards. The technique of nanofiltration can be used to lower the TDS of water[12]. The variation in TDS is shown in Figure-3 while the correlation of conductivity and TDS is shown in Figure-4. The linear regression relationship between conductivity and TDS is usefull to estimate TDS of water samples from conductivity measurement[13].

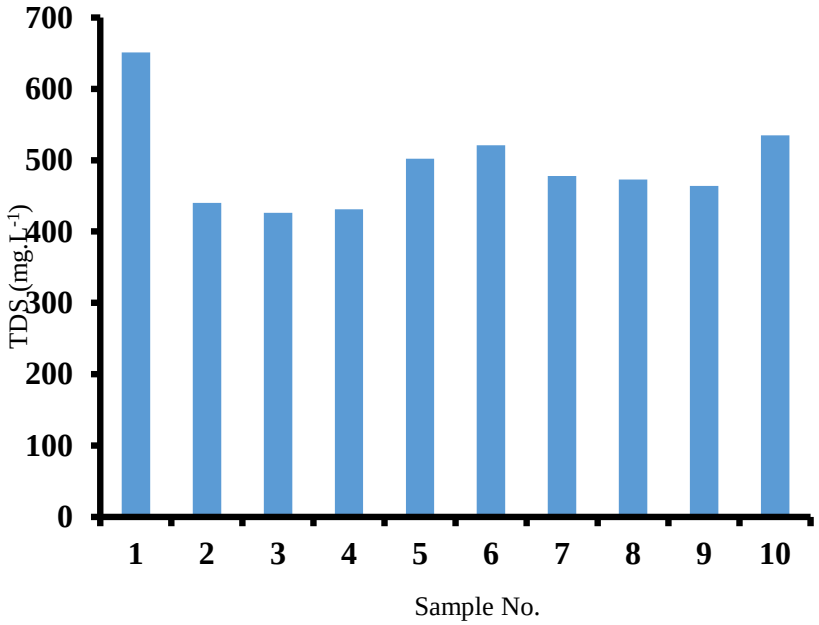

Fig.3: The TDS variation of water samples from different locations inside Gulshan-e-Iqbal Town

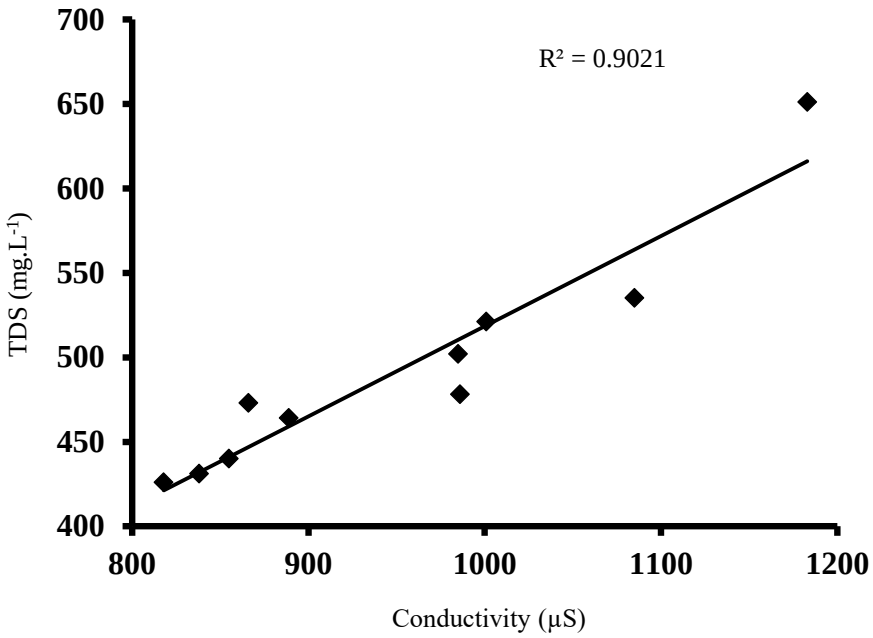

Fig.4: The correlation of conductivity and TDS (R^2 = 0.902)

4.4 *Total Alkalinity*

The alkalinity of water is its capability to neutralize acids and is due to the presence of CO_3^{2-}, HCO_3^- and OH^- species. The alkalinity of a water sample is very important as the water reservoirs are often subject to acidic effluents from industrial houses. The WHO recommended value of alkalinity for a water sample is 120 $mg.L^{-1}$. In our study, the alkalinity of water samples was in the range of 90 to 160 $mg.L^{-1}$ which although a little higher than WHO limits but does not poses any health hazards to its consumers.

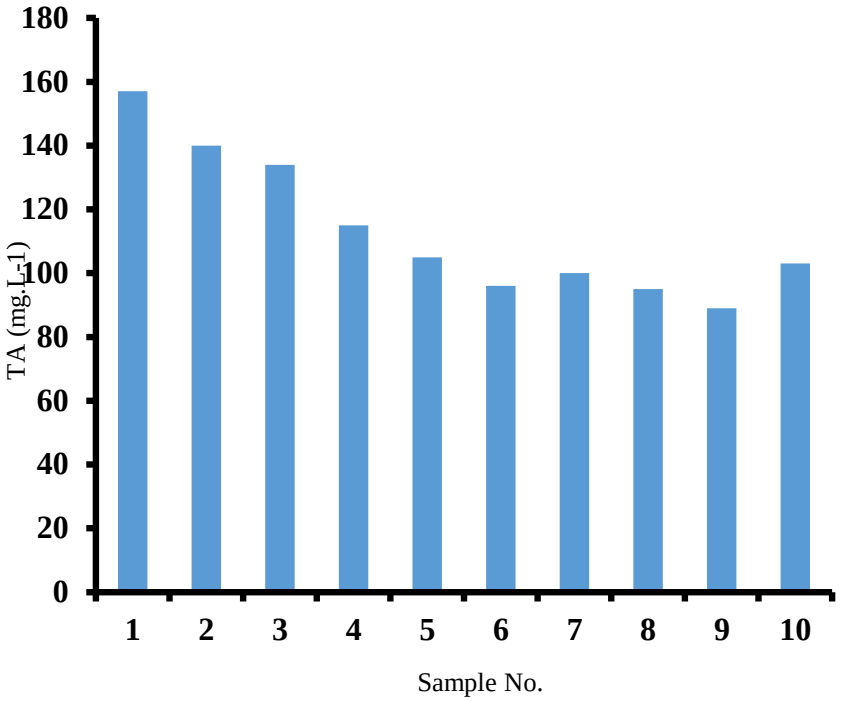

Fig.5: The variation in total alkalinity of water samples from different locations inside Gulshan-e-Iqbal Town

4.5 *Sodium*

The sources of sodium in ground water are rocks and waste water of industrial and domestic origin. The concentration of sodium in drinking water is usually not a health issue except for people with hypertension and cardiac irregularities. However, drinking of high sodium water on regular basis may cause arteriosclerosis, oedema and hyperosmolarity[14]. In our study, the concentration of sodium ions in the water samples was as per the WHO and PSQCA standards.

4.6 *Potassium*

The potassium ions in water have the ability to impart laxative effects on the consumers and hence its concentration in drinking water must be monitored. The WHO does not provide any guideline for the concentration of potassium in drinking water but the PSQCA limit is 10 $mg.L^{-1}$. In our study, the concentration of potassium was according to the PSQCA standards.

4.7 *Calcium*

The calcium ions are introduced in ground water from deterioration of igneous rocks. The excess of calcium in drinking water can cause stomach disorders and also combination of Ca^{2+} ions with either sulphate and phosphate ions has the potential to produce kidney stones. The calcium ions have the ability to impart a pleasant sweet taste to the water. The concentration of calcium ions is directly related to the hardness of water. In our study, no sample was found to contain calcium in concentration higher than the WHO and PSQCA standards but there was significant variation in the concentration of calcium in different samples.

4.8 *Magnesium*

The natural water contains a definite concentration of magnesium as a result of dissolution of rocks composed of magnesium salts. The magnesium ions play a vital role in many biological activities inside the human body and are also required for the growth of phytoplanktons. An excess of magnesium in drinking water can cause stomach disorders. In our study, the concentration of magnesium in ground water samples was in the range of 4 – 20 $mg.L^{-1}$ which is satisfactory as per WHO and PSQCA drinking water standards. The calcium and magnesium ions are responsible for the hardness of water. Furthermore, these ions interact with the toxic elements in water and reduce their poisonous effects[15].

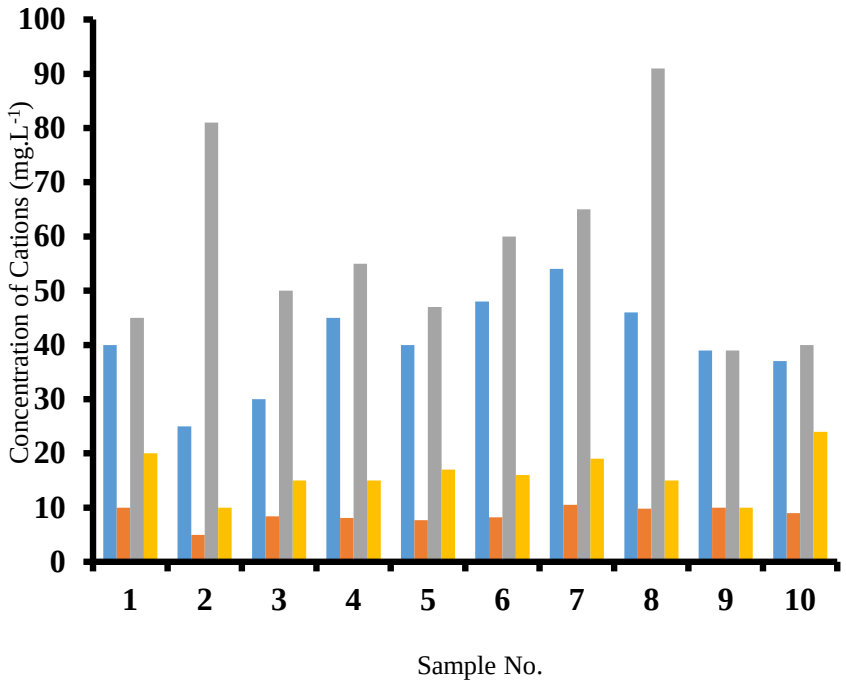

Fig.6: The variation in concentration of different cations in water samples

4.9 *Sulphate*

The sulphate ions are discharged into water streams from deterioration of rocky deposits and also by adulteration of water streams from industrial effluents[16]. Some sulphates are insoluble in water and cause choking of water supply pipelines. The maximum recommended value of sulphate in drinking water by WHO and PSQCA is 250 $mg.L^{-1}$. In our study, the concentration of sulphate in all the samples complied with the WHO and PSQCA standards.

4.10 *Chloride*

The main source of chloride in ground water are the industrial and domestic effluents containing chloride salts but some rocks also contribute to sodium content of ground water[17]. An excess of chloride in drinking water is likely to produce laxative effects. The maximum recommended value of chloride in drinking water by WHO and PSQCA is 250 $mg.L^{-1}$. In our study, all the samples complied with the WHO and PSQCA standards.

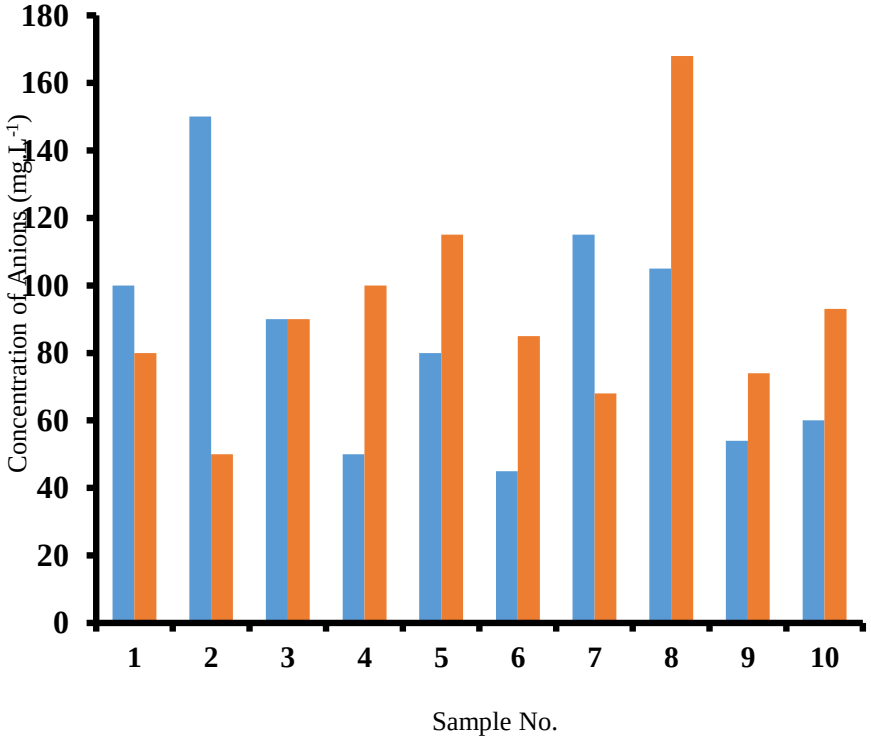

Fig.7: The variation in concentration of different anions in water samples

5. MICROBIOLOGICAL EXAMINATION

The water samples were microbiologically examined for total viable plate count (TVPC) as indicator of its total microbial contamination and for E coli and P aeruginosa as pathogenic bacteria. The water samples were inoculated on bacteriological media suitable for the growth of microorganisms and were incubated for 48 hours so that bacterial colonies can grow and then subsequently get counted. In the present study the bacteriological examination of 10 different water samples was carried out, of which 3 (30%, Table-3) of these samples did not comply with the standard guidelines of Pakistan and WHO for drinking water. In these specimens TVPC at 37^{o}C was found higher than the recommended range which is < 20 cfu/mL. TVPC count displays the presence of heterotrophic bacteria in the ground water samples, which indicates the bacterial pollution of drinking water[18]. Heterotrophic bacteria are non pathogenic but there are chances that the higher heterotrophic bacterial count may be associated with the presence of coliform bacteria or other pathogens. However *E coli* and *P aeruginosa* were not found in the tested samples.

Table-3: Microbiological Water Quality Parameters of Ground Water in Different Areas of Gulshan-e-Iqbal

Sample No	Sample	CFU/mL	Interpretation
01	Gulshan-e-Iqbal Block 2 (Home)	No growth	Potable
02	Opposite Aladdin Park (Home)	10^2	Potable
03	Sohrab Goth (Home)	$< 10^2$	Potable
04	National stadium	$\geq 10^2$	Non-Potable
05	Hasan Square (Home)	$\geq 10^2$	Non-Potable
06	PCSIR	$< 10^2$	Potable
07	Federal Urdu University	$< 10^2$	Potable
08	Nipa Chworangi (Home)	No growth	Potable
09	Bait-ul-Mukharram Mosque	$< 10^2$	Potable
10	Bahadurabad	$\geq 10^2$	Non-Potable

6. CONCLUSION

The physico-chemical parameters of ground water samples from different location inside Gulshan-e-Iqbal town of Karachi city were analyzed and the experimental values were compared with the WHO and PSQCA drinking water quality standards. All the ten samples complied with the WHO and PSQCA standards except one sample which had higher TDS than PSQCA standards. In the microbiological examination of ground water sample 3 samples (30%) did not comply with the standard guidelines of Pakistan and WHO for drinking water. Therefore, it can be concluded that the 70% ground water reservoirs from which these water samples were collected can be safely be used for drinking purpose on the basis of their physical properties, chemical composition and microbiological examination.

7. REFERENCES

1. Annapoorani, A., Murugesan, A., Ramu, A., Renganathan, N. G. Hydrochemical Characteristics of Groundwater Quality in Chennai City Using Gis– A Case Study, Int. J. Res. Chem. Environ., 3(4), 39-47, **(2013)**.
2. Sunil, K. and Rajesh, D. Variation in Physico-chemical characteristics of water quality of Bhindawas Wetland, Jhajjar, Haryana, India, Res. J. Chem. Sci., 5(7), 29-34 **(2015)**.
3. Kumar, B. A. Comparative study of heavy metals on Chilar and Lakhundar Dam at Shajapur District, MP, India, Res. J. Chem. Sci., 5(6), 56-58, **(2015)**.
4. Lilly, P. F., Paulraj, A., Ramachandramoorthy, T. Assessment of Ground Water Quality of Salem Taluk in Salem District, Tamil Nadu, India Int. J. Res. Chem. Environ., 2(4), 323-337, **(2012)**.
5. Balamurugan, C., Dheenadayalan, M. S. Groundwater quality and its suitability for drinking and agricultural use in Vaigai River basin at Madurai, Tamil Nadu, India, J. Chem. Bio. Phys. Sci., 2(2) 1073-1078, **(2012)**.
6. Jehan, N., Israr, M., Gul, N., Shams, H., Shafiq-U-Rehman, S., Khan, S. J. Assessment of physiochemical characteristics of drinking water quality in Kohat Development Authority, NWFP, Pakistan, Himalayan Earth Sci., 42, , 45-52, **(2009)**.
7. Ramesh, C. P., Philip, G. H. Analysis of water quality parameters of Lakshmipuram tank, Anantapuramu (d), Andhra Pradesh, India, Res. J. Chem. Sci., 5(4), 26-32 **(2015)**.
8. Aftab, T., Shafiq, T., Khan, B., Chaudhry, M. N. Physicochemical properties, contamination and suitability of canal water for irrigation, Lahore branch Pakistan, Pak. J. Anal. Environ. Chem., 12, 88-94, **(2011)**.
9. Asadullah, Kherun-Nisa, Khan, S. I. Physico-chemical properties of drinking water available in educational institutes of Karachi city, Sci. Tech. and Dev., 32(1), 28-33, **(2013)**
10. Piplode, S. and Barde, V. S. Physico-chemical evaluation of Narmada River water at Khalghat MP, India, Res. J. Chem. Sci., 5(5), 24-26, **(2015)**
11. Goncharuk, V. V., Kavitskaya, A. A., Skilskaya, M. D. Nanofiltration in drinking water supply, J. Water Chem. Tech., 33(1), 37-54, **(2011),** http://dx.doi.org/10.3103/S1063455X11010073.

12. Mishra, A., Assessment of water quality using principal component analysis: A case study of the river Ganges, J. Water Chem. Tech., 32(4), 227-234, **(2010),** http://dx.doi.org/10.3103/S1063455X10040077.
13. Zahid-Ullah, Khan, H., Waseem, A., Mahmood, Q., Farooq, U. J. Water quality assessment of the River Kabul at Peshawar, Pakistan: Industrial and urban wastewater impacts, J. Water Chem. Tech., 35(4), 170-176, **(2013),** http://dx.doi.org/10.3103/S1063455X1304005X.
14. Ramesh, K., Seetha, K. Hydrochemical Analysis of Surface water and Groundwater in Tannery belt in and around Ranipet, Vellore district, Tamil Nadu, India, Int. J. Res. Chem. Environ., 3(3), 36-47, **(2013)**.
15. Parihar, S. S., Kumar, A., Kumar, A., Gupta, R. N., Pathak, M., Shrivastav, A., Pandey, A, C. Physico-Chemical and microbiological analysis of underground water in and around Gwalior city, MP, India, Res. J. Recent Sci., 1(6), 62-65, **(2012)**
16. Nosheen, S., Alam, S. Irfan, M., Usman, M., Qureshi, A., Muhammadzai, I. Ionic Characteristics of Potable Water of Mardan District, Pak. J. Chem., 3(2), 71–74, **(2013)**.
17. Khuhawar, M. Y., Majidano, S. A. An Investigation of Quality of Groundwater of Taluka Nawabshah Pak. J. Chem., 1(2) 65–71, **(2011)**.
18. Khatoon, A., and Pirzada, Z. A. Bacteriological quality of bottled water brands in Karachi, Pakistan. Biologia, 56, 137-143, **(2010)**.