Octa Journal of Environmental Research **Jan – Mar., 2016**
International Peer-Reviewed Journal ISSN 2321 3655
Oct. Jour. Env. Res. Vol. 4(1): 008-017
Available online http://www.sciencebeingjournal.com

Research Article

Octa Journal of Environmental Research
(Oct. Jour. Env. Res.) ISSN: 2321-3655
Journal Homepage: http://www.sciencebeingjournal.com

APPLYING STATISTICAL TOOLS FOR THE ASSESSMENT OF GROUNDWATER QUALITY IN AND AROUND PATIALA CITY OF PUNJAB, INDIA

Abhimanyu Singh[a], Kailash C. Bhatt[a], A.H. Khan[b], Indu[a], Swati Gupta[a], Surabhi Surya[a] and Jamshed Zaidi[a]

a. Institute of Environmental and Development Studies, Bundelkhand University, Jhansi-284128.
b. Indian Institute of Toxicology Research Center, Lucknow-226003
Corresponding Author's Email: **jamshed_zaidi08@rediffmail.com**
Received: 26th Feb. 2016 **Revised**: 29th Feb. 2016 **Accepted**: 7th Mar. 2016

Abstract: Present study was focused to monitor the potable groundwater quality in the selected sites along Patiala-Baadi River, which is running across the Patiala city. Since 3-4 decades the various type of effluent comes from industrial, domestic in addition to agricultural runoff. The work have been carried out to study physico-chemical characterizes *viz*. pH, EC, TDS, F, Cl, Na, Zn, and Fe to evaluate the groundwater quality and their statistical correlation. The calculation of WQI (water quality Index) is 45.18 and it comparing with Indian Standard Drinking Water (IS 10500: 2012), results groundwater quality of Patiala city in the range of slightly polluted which are not suitable for drinking purposes without treatment but it is suitable for agricultural and other domestic purposes. During investigation, correlation of TDS has been worked out with rest of analyzed water quality parameters and it shows positive correlation.
Keywords: Groundwater, Heavy metals; Patiala city; Physico-chemical parameters, WQI.
Postal Address: Institute of Environmental and Development Studies, Bundelkhand University, Jhansi-284128.

INTRODUCTION

Water plays an important role in the development of a healthy society. About 97.6% of oceanic water on the earth is present as salty and 2.4% fresh water only in which about 0.5% constitutes groundwater. Studies carried out in India revealed that one of the most important causes of groundwater pollution is unplanned urban development without adequate attention to sewage and waste disposal from industries and other sources as well. The incidence of groundwater pollution is highest in urban areas where large volume of wastes generated and discharged into relatively small areas (Abdullah *et al.,* 2012). In India, majority of industries and cities are located along rivers. There are 142 major cities in India of which 112 lie on river basins, 17 are coastal and 13 non-coastal (Fokmare and Mussaddiq, 2001). In our country municipal corporation provided facilities for the drinking water in urban population. But now-a-days, Municipal Corporation provided drinking water in limited area so the people choose to other option such as hand pumps and jet pumps. For last few years, it has been seen that the groundwater quality deterioration day by day and its responses in the form of uncommon odour and yellowish color of water. In this area, people use chlorine tablets for disinfected the drinking water and some other treatment methods. According to Gupta and Gupta (1999), Rajasekara *et al.,* (2005), Rajan and Paneerselvam (2005), Shikha *et al.,* (2007), Xiao-Yan *et al.,* (2006) and Mor *et al.,* (2009) were monitoring the groundwater at periodic interval of time at national and international level to know the pollutant content in drinking water as the rapid growth of urban areas and further affected the groundwater quality due to over exploitation of resource with improper waste disposal practices. With this background, present study has been undertaken for examine the groundwater quality of Patiala city of Punjab.

Patiala is a city located in south-eastern part of Punjab state in northern India having a population of 1,844,934 and rank the 6th most populated district of the Punjab. It lies between 29^{0}49’N to 30^{0}47’ N latitudes and 75^{0}58’E to 76^{0}54’ E longitudes (*https://en.wikipedia.org/wiki/Patiala*). Most of the area is plain in the form of agricultural land and industrial sectors along rivers. Patiala-Baadi-Nadi is the river which running across the maximum part of Patiala. In the study area, twelve sampling locations are selected and their distances from the Patiala-Baadi-Nadi given in below Table 1 and Figure 1.

Table 1. Sampling locations and their distance from Patiala-Baadi-Nadi, in Punjab

S.No.	Location	Distance from Patiala-Badi River (Km)	Location Code/s
1.	Mathura Colony	2.5	GW1
2	Aman Nagar	2.5	GW2
3.	Gurubaksh Colony	2.0	GW3
4.	Marcel Colony	2.0	GW4
5.	Guru Nanak Nagar	1.5	GW5
6.	Ekta Nagar-B	1.0	GW6
7.	Urban Estate	1.0	GW7
8.	Tejbag Conoly	1.0	GW8
9.	Shanti Nagar	0.5	GW9
10.	Rangeshah Colony	0.5	GW10
11.	S.S.T. Nagar	0.5	GW11
12.	Transport Nagar	0.5	GW12

Figure 1. Shows map of Patiala City and their Sampling sites

Table 2. Categories the water quality index (WQI) with range of Pollution (Sinha, *et al.,* 2004)

I	If, water quality index (WQI) is less than 50 such water is slightly polluted and fit for human consumption.
II	WQI between 51-80 indicate moderately polluted.
III	WQI between 80-100 shows excessively polluted and WQI- severely polluted.

Table 3. Hi Media Kit and their specific range of water analysis

S.No.	Type of test	Range	Reagent Provided
1.	pH	pH test strips of range 2.0 to 10.5	-
2.	Chloride (Titration method)	-	4 reagent bottles: marked CHL-A, CHL-B, CHL-C (2 bottles)
3.	Total hardness (Titration method) CaCo3	25-600 mg/L	4 reagent bottles: marked TH-A, TH-B, TH-C (2 bottles)
4.	Fluoride (visual colour comparision method)	0-2.5 mg/L	2 Reagent bottles: marked reagent FL-A, FL-B
5.	Nitrate (visual colour comparision method)	0-100 mg/L	One reagent bottle : marked reagent N
6.	Iron (visual colour comparision method)	0-2 mg/L	One reagent bottle : marked reagent Fe
Selected parameters with Standard method			
7.	Electrical conductance	Conductivity meter	IS:30025 (Part 11):1983
8.	Total dissolved solids	Gravimetric	IS:3025 (Part 16):1984
9.	Suphate	Colorimetric	IS:3025 (Part 24):1986
10.	Alkalinity	Titrimetric	IS:3025 (Part 23):1986
11.	Zinc	AAS Method	IS:3025 (Part 49):1994
12.	Sodium	Flame Photometric	IS:3025 (Part 45):1993

EXPERIMENTAL

Calculation of WQI: Octa-aqua HI-media kit having eight water parameters and also applying another methods for other parameters were analysed for calculation of water index (Harkins, 1974; Tiwari *et al.,* 1986; Tiwari and Manzor, 1988; Mohanta and Patra, 2000; Kesharwani *et al.,* 2004; Padmanabha and Belagalli, 2005). The Water quality Index (WQI) and Water quality rating (Qi) can be calculated as:

$$\mathbf{WQI = \sum QiWi}$$

And

$$\mathbf{Qi = 100x\ (Va\text{-}Vi) / (Vs\text{-}Vi)}$$

Where

Va= actual value present in the water sample

Vi= ideal value (0 for all parameters except pH and DO which are 7.0 and 14.6 mg/L.

Vs= Standard value. If quality rating.

Qi= 0 means complete absence of pollutants

While 0<Qi<100 implies that the pollutants are prescribed standard.

When Qi> 100 implies that the pollutants are above the standards.

$$\mathbf{Wi\ (Unit\ weight) = K/Sn}$$

Where K is constant

$$K\ (\text{constant}) = \frac{1}{1/Vs1 + 1/Vs2 + 1/Vs3 + 1/Vs4 \ldots + 1/VS_n}$$

Sn= 'n' number of standard values.

According to Sinha *et al.,* (2004), the range of water quality index (WQI) is given in Table 2.

Techniques of sample analysis: Physical and chemical properties of groundwater have been done according to standard methods (APHA, 2005) and Hi-Media (WT-023) kit and their specific range for water analysis is given Table.3.

Statistical Analysis

Pearson's Correlation: Pearson correlation coefficient is commonly used to measure and establish the strength of a linear relationship between two variables or two sets of data. It is a simplified statistical tool to show the degree of dependency of one variable to the other (Belkhiri *et al.,* 2010). The Pearson correlation coefficient (r xy) is computed by using the formula as given (Patil and Patil, 2010; Jothivenkatachalam *et.al.,* 2010; Kumar and Sinha, 2010). The correlation co-efficient 'r' was calculated using the equation given below.

$$r_{xy} = \frac{n\sum (x_i\, y_i) - (\sum x_i).(\sum y_i)}{\sqrt{[n\sum x_i^2 - (\sum x_i)^2]\,[n\sum y_i^2 - (\sum y_i)^2]}}$$

Where, x_i and y_i represents two different parameters. **n**= Number of total observations.

The inter dependence of different water quality parameters on each other was evaluated on the basis of above **r** $_{xy}$ equation. The correlation coefficient is always between -1 and +1. A correlation closer to +/- 1 implies that the association is closer to a perfect linear relation. Interpretation of the Pearson correlation coefficients, adopted in the present study are: r = -1 to -0.7 (strong negative association); r = + 0.7 to + 1.0 (strong positive association); r = -0.7 to -0.3 (weak negative association); r = + 0.3 to + 0.7 (weak positive association); r = - 0.3 to + 0.3 (negligible or no association). Thus, for the twelve water quality parameters, the possible correlations between every pair were computed using SPSS Statistics Software (Version 17.0) and arranged into a correlation matrix.

Linear Regressions: In this study, we have applied the linear regression approach to develop a relationship between several independent/ predictor variables and a dependent/ predict and variable. This method is successfully used by different authors to establish statistical model (Ghasemi and Saaidpour, 2007).

RESULTS AND DISCUSSION

pH: The pH of water is a measure of the acid-base equilibrium and, in most natural water is controlled by the carbon dioxide-bicarbonate-carbonate equilibrium system. An increased carbon dioxide concentration will therefore lower pH, whereas a decrease will cause it to rise. The pH of most water lies within the range 6.5-8.5. The condition of ground water is moderately alkaline in nature. During the investigation, pH was found in most of the samples ranges between 7.12 to 7.59. The pH value of most of locations is moderately alkaline in nature and all value are well within the describe and permissible limit as compare with IS:10500 standard for drinking purpose.

Electrical Conductivity (EC): Electrical conductivity (EC) is a measure of the total salt content of water based on the flow of electrical current through the sample. The higher the salt content, greater will be the flow of electrical current. It is low to moderately mineralize as conductivity of water sample at 25^0C (WHO, 2011). Result shows the average concentration of electrical conductivity varies from 878-1954 µs/cm for all locations during the study.

Total Dissolved Solids (TDS): TDS is the term used to describe the inorganic salt and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium and potassium cations and carbonate, hydrogen- carbonate, chloride, sulphate and nitrate anions. Average concentration of TDS varies from 500-1270 mg/L for all analyzed samples of the study area.

Fluoride (F^-): Fluoride is the lightest member of the halogen group and is one of the most reactive of all chemical elements. Fluoride is found in all natural waters at some concentration. Seawater typically contains about 1 mg/L while rivers and lakes generally exhibit concentrations of less than 0.5 mg/L. In this study, the fluoride content of the selected monitoring sites is varies from 0.14-2.08 in groundwater however, low or high concentration of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride –bearing minerals are common.

Chlorides (Cl^-): Chlorides have constituted the almost of anions of natural waters which may come as pollution across sanitary and Industrial water. Chloride is found widely distributed in nature in the form of salt of sodium, potassium and calcium. Inland natural waters have low chloride concentration. In our study, chlorides recorded between 170 to 270 mg/L.

Sulphate (SO_4^{-2}): Sulphates occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4.7H_2O$) and gypsum ($CaSO_4.2H_2O$). These dissolved minerals contribute to the mineral content of many drinking waters. The result concentration of sulphate varies from 136-220 mg/L for all analyzed samples.

Nitrate (NO_3^-): In the study area, groundwater contains nitrate due to weathering and leaching of nitrate bearing minerals and other by the percolating water. Groundwater can also be contaminated by sewage and other wastes which rich in nitrate. The nitrate content in the study area varied in the range between 171 to 299 mg/L

Total Hardness (TH): Hardness of water mainly depends upon the amount of calcium or magnesium salt or both. The hardness value of this groundwater was shown from the range of 203 to 403 mg/L.

Alkalinity: Alkalinity is a measure of the capacity of water to neutralize acids. Alkaline compounds in the water such as bicarbonates, carbonates and hydroxides remove H^+ ions and lower the acidity of the water. They usually do this by combining with the H^+ ions to make new compounds. Without this acid-neutralizing capacity, any acid added to a stream would cause an immediate change in the pH. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or waste water. It's one of the best measures of the sensitivity of the stream to acid inputs. During investigation, average concentration of total alkalinity in groundwater samples varies from 191 to 444 mg/L.

Sodium (Na): The sodium ion is ubiquitous in water. Sodium is essential to human life. There is no agreement on the minimum daily requirement. However, it has been estimated that a total daily intake of 120-400 mg will meet the daily needs of growing infants and young children and 500 mg dose for adults. Most water supplies contain less than 20 mg of sodium per liter, but in some other countries. Na levels can exceed 250 mg/L. Average concentration of sodium varies from 28-62 mg/L for all locations in the study area.

Zinc (Zn) and Iron (Fe total): Metals are inorganic substances that occur naturally in geological formations. Some metals are essential for life and others are naturally available in our food and water. In addition to, some of metals is known essential for life in drinking water may contain excess metals which cause chronic or acute poisoning. Metals such as Zn and Fe were analyzed and found 0.22 to1.80 mg/L and 0.15 to 0.60 mg/L respectively which were within the permissible limits.

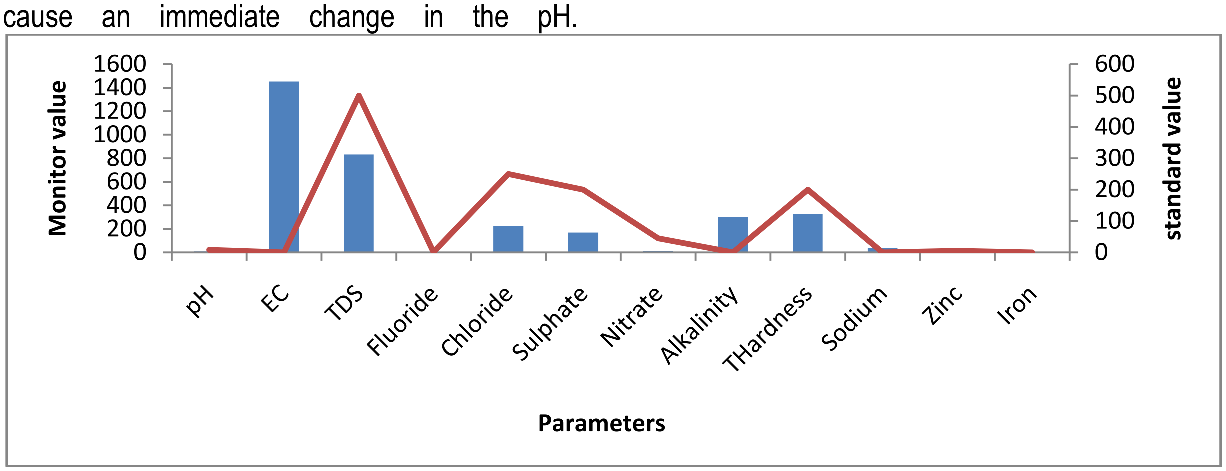


Figure 2. Comparison of Groundwater Quality levels with IS 10500:2012 (Water Quality Standard)

Table 4. Groundwater quality parameters of different sampling sites in and around Patiala city, Punjab

#	Study area → Parameters ▼	GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GW9	GW10	GW11	GW12	IS 10500: 2012	WQI
1.	pH	7.12±.4	7.24±.2	7.18±.2	7.25±	7.26±	7.13±	7.59±	7.42±	7.56±	7.25±	7.45±	7.30±	6.5-8.5	45.18
2.	EC (µs/cm)	878±22	893±16	963±19	1219±28	1254±24	1315±22	1531±27	1804±21	1808±20	1954±19	1908±31	1904±34	-	Slightly
3.	TDS, (mg/L)	500 ±7	580±11	542±9	599±8	587±14	683±13	721±15	1219±22	1187±24	1009±28	1112±19	1270±27	500	Polluted
4.	F^- (mg/L)	0.24±.01	0.14±.01	0.15±.01	0.40±.01	0.16±.02	0.83±.03	0.14±.01	1.04±.03	1.38±.02	1.70±.02	1.62±.01	2.08±.04	1.0	
5.	Cl^- (mg/L)	170±3	209±5	211±6	188±8	233±3	231±2	215±3	232±2	228±5	258±2	236±3	299±4	250	
6.	SO_4^{--}(mg/L)	137±2	136±2	142±3	175±5	139±2	164±6	159±3	210±6	203±2	181±4	182±2	220±7	200	
7.	NO_3^-(mg/L)	9.17±.6	5.67±.6	6.67±.5	7.50±.2	7.30±.6	12.83±.9	11.17±.3	11.17±.2	12.87±.3	15.17±.1	16.50±.3	15.67±	45	
8.	Alkalinity(mg/L)	192±7	217±4	213±3	237±6	190±4	253±5	234±9	443±5	392±7	401±12	435±8	426±6	……..	
9.	TH (mg/L)	244±5	224±2	275±12	311±14	308±9	296±11	338±16	367±14	371±16	394±18	402±13	403±17	200	
10.	Na (mg/L)	28±.8	36.67±1	28.33±3	35.67±4	48.67±1	34.83±2	44±3	44±2	55±2	52±5	53±3	62±5	…..	
11.	Zinc(mg/L)	0.68±.02	00	0.62±.02	0.87±.01	0.00	1.03±.03	0.68±.01	0.22±.01	1.80±.02	1.48±.01	1.60±.02	1.77±.02	5	
12.	Fe* (mg/L)	0.37±.01	.15±.01	0.43±.01	0.23±.01	0.32±.02	0.56±.01	0.37±.01	0.52±.01	0.43±.01	0.45±.02	0.47±.01	0.60±.01	0.3	

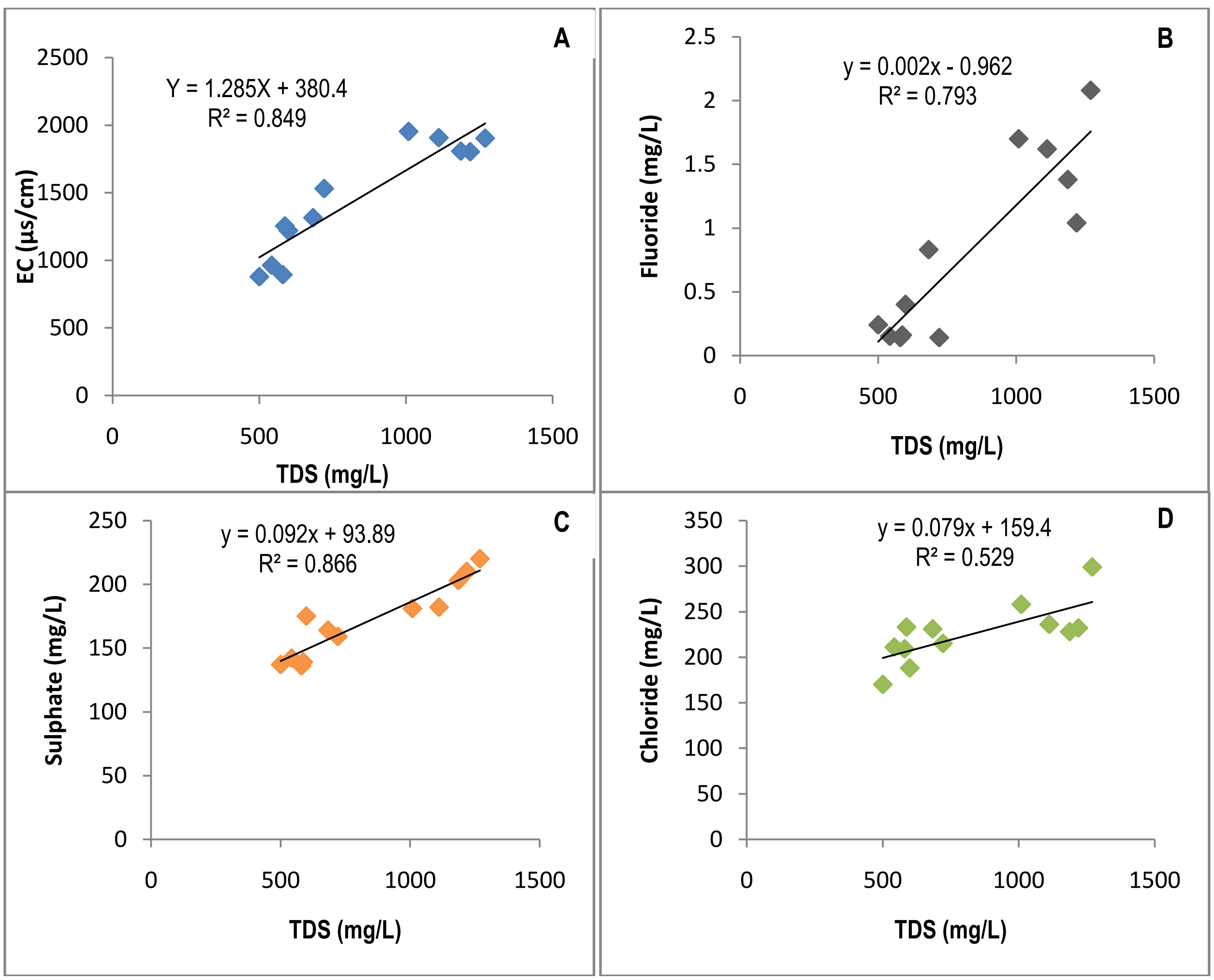
Fe*: Total Iron

Table 5. Correlation Coefficient Matrix between Different Physico-chemical parameters of Groundwater in and around Patiala city, Punjab

S.No		pH	EC	TDS	F^-	Cl^-	SO_4^{--}	NO_3^-	Alkalinity	TH	Na^+	Zn^{++}	Fe^-
1	pH	1	0.608	0.571	0.258	0.205	0.482	0.365	0.478	0.579	0.574	0.273	0.095
2	EC	0.608	1	0.922	0.869	0.741	0.855	0.871	0.913	0.978	0.864	0.669	0.623
3	TDS	0.571	0.922	1	0.891	0.727	0.931	0.790	0.972	0.881	0.822	0.630	0.642
4	F	0.258	0.869	0.891	1	0.786	0.839	0.897	0.912	0.851	0.788	0.816	0.685
5	Cl^-	0.205	0.741	0.727	0.786	1	0.654	0.676	0.678	0.732	0.822	0.497	0.642
6	SO_4^{--}	0.482	0.855	0.931	0.839	0.654	1	0.710	0.896	0.840	0.715	0.641	0.629
7	NO_3^-	0.365	0.871	0.790	0.897	0.676	0.710	1	0.810	0.849	0.710	0.822	0.754
8	Alkanity	0.478	0.913	0.972	0.912	0.678	0.896	0.810	1	0.875	0.747	0.637	0.626
9	TH	0.579	0.978	0.881	0.851	0.732	0.840	0.849	0.875	1	0.853	0.698	0.629
10	Na^+	0.574	0.864	0.822	0.788	0.822	0.715	0.710	0.747	0.853	1	0.584	0.408
11	Zn^{++}	0.273	0.669	0.630	0.816	0.497	0.641	0.822	0.637	0.698	0.584	1	0.561
12	Fe^-	0.095	0.623	0.642	0.685	0.642	0.629	0.754	0.626	0.629	0.408	0.561	1

Correlation Analysis

The correlation analysis study involving statistical calculation was devised by Pearson (1896). Based on the value of correlation coefficient 'r' indicate the correlation between two variable parameters plotted on a XY scatter diagram can be termed as positive or negative. Correlation analysis is a common and useful statistical tool for water quality studies indicating which ions control the water chemistry (Box *et al.,* 1978; Chapman 1996; Shrivastava and Patil 2002; Zeng *et al.,* 2005). It is simply a measure to exhibit how well one variable predicts the other (Kurumbein and Graybill 1965). In the present study, correlation of TDS has been worked out with rest of the analyzed water quality parameters and the following observations have been made from the trend analysis graphs (Figure 3). The correlation coefficient matrices prepared during investigation is given in Table 5. TDS is observed to share a positive correlation with pH (r = 0.571), total alkalinity (r = 0.913), EC (r=0.922), F (r = 0.869), Cl (r= 0.741), SO_4 (r=0.855), NO_3 (r= 0.871), TH (r=.978), Na (r=.864), Zn (r=.669) and Fe (r=.623). Same trend was also recorded by (Zaidi and Pal, 2015; Shreya and Nag, 2015).



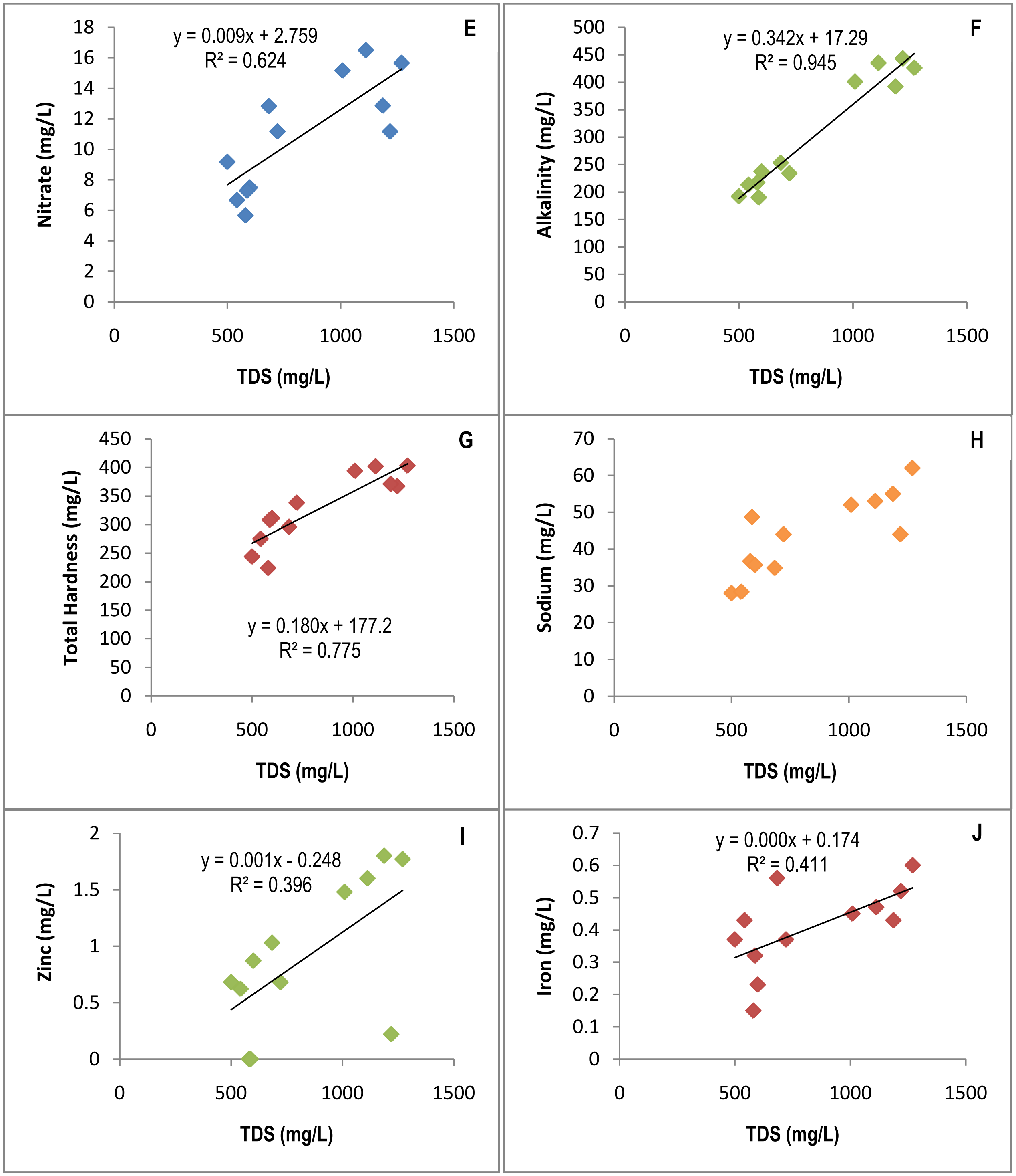


Figure 3. Correlation Analysis: Graphs presenting correlation trends of TDS with other analyzed Water Quality parameters

A.TDS shows strong correlation with EC (0.84); **B**. TDS shows strong correlation with Fluoride (0.79); **C.** TDS shows strong correlation with Sulphate (0.86); **D.**TDS shows strong correlation with Chloride (0.52); **E.** TDS shows strong correlation with Nitrate (0.62); **F** TDS shows strong correlation with Alkalinity (0.94); **G.** TDS shows strong correlation with Total Hardness (0.77); **H.** TDS shows strong correlation with Sodium (0.67); **I.** TDS shows weak correlation with Zinc (0.396); **J.** TDS shows weak correlation with Iron (0.41).

CONCLUSION

Water is essential natural resource for sustaining life ground water is purer in comparison of surface water. Adequate supply of potable safe water is absolutely essential and is the basic need for all human being. The water quality is a consequence of natural physical and chemical state of water as well as alterations caused by human activities. Multipurpose water are uses for various requirement in different standard of water quality and their water quality criteria define desirable characteristics and acceptable levels of constituents for water of various intended uses. Present study was carried out to assess the impact of Patiala-Baadi-Nadi on groundwater quality near it vicinity. Samples were collected private bore well having the depth of 150-200 feet to maintain the depth uniformity, at periodic intervals of time up to six month for 12 different locations as per IS guidelines. The groundwater quality of Patiala is poor for drinking purpose as per water quality index (45.18). So this water can be used for drinking purpose after purification treatment. Results also show that the quality of groundwater used specially for irrigation will be good but not in drinking purpose. Continuous water quality monitoring in the study area is encouraged, increasing the frequency of sampling and also analysis on the study area is needed to effectively monitor the impact on Patiala city area, particularly on environment and human health.

Acknowledgements: The authors are very much thankful to Dr.G.C. Kissu, Scientist EII, Environmental Monitoring division, IITR Lucknow for their critical discussions and constructive suggestion during preparation of the manuscript.

REFERENCES

Abdullah S., Asef I. M., Ilyas M., Shejule K.B. and Rehana A. (2012). Groundwater pollution at Beed, Maharastra as an effect of MSW dumping *Bull. Evn. Phaemacol. Life Scien.*12:43-46.

APHA (2005), Standard methods for examination of water and wastewater, 21st Ed. American Public Health Association, Washington.

Belkhiri L., Boudoukha A. and Mouni, L. (2010). A multivariate Statistical Analysis of Groundwater Chemistry Data, *International Journal of Environmental Research.* 2: 537-544.

Box G.F.P., Hunter W.G. and Hunter J.S. (1978) Statistics for experiments. An introduction to design data analysis and model building. Wiley, Toronto, 653.

Chapman D (Ed) (1996). On the behalf of UNESCO, WHO. UXEP. Water quality assessments—a guide to use biota, sediments and water in environmental monitoring. F&F Spoil, London, Chapter 9

Kurumbein WC, Graybill FA (1965). An introduction to statistical models in geology. McGraw-Hill, New York

Fokmare A.K. and Mussaddiq M. (2001). Levels of Ammonia and Phosphates as indicators oforganic pollution of river Morna at Akola (Maharastra). *Environ. Poll. Ctrl. J.* 4:20-21.

Ghasemi, J. and Saaidpour S. (2007). Quantitative structure-property relationship study of n-octanol-water partition coefficients of some diverse drugs using multiple linear regression, *Analitica Chimica Acta.* 2: 99-106.

Gupta B.K. and Gupta R.R. (1999). Physio-chemical and biological study of drinking water in Satna, Madhya Pradesh. *Poll. Res*. 18: 523-525.

Harkins R.D. (1974): An objective water Quality Index. *J. Water Pollut. Contr. Fedr*., 46, 589.

Jothivenkatachalam K., Nithya A.and Chandra Mohan S., (2010). Correlation analysis of drinking water quality in and around Perur block of Coimbatore District, Tamil Nadu, India, *Rasayan Journal Chemistry* 4:649-654.

Kesharwani S., Mandoli A. K. and Dude K. K. (2004). Determination of water quality Index (WQI) of Amkhera pond of Jabalpur city (M.P.) *Ntl. J. Life Sci.* 1: 61-66.

Kumar, N. and Sinha, D.K. (2010). Drinking water quality management through correlation studies among various physicochemical parameters: a case study, *International Journal of Environmental Sciences.*2: 253-259.

Mohanta B. K. and Patra A.K. (2000). Studies in the water Quality index of River Sanamachha

Kananda at Keonjargarh at Orissa, India. *Pollut. Rex.* 19:377-385.

Mor S., Singh S., Yadav P., Rani P., Rani V., Sheoram M., Singh G. and Ravindra K. (2009). Apprasial of salinity and fluoride in a semi arid region of India using statistical and multivariate techniques. *Environ Geochem Health*. 6:643-55.

Padmanabha B. and Belagali S.L. (2005). Comparative study on the water quality index of fur lakes in the Mysore city. *IJEP.* 25: 873-876.

Patil V.T. and Patil P.R. (2011). Groundwater quality of open wells and tube wells around Amalner town of Jalgaon, District, Maharashtra, India, *Electronic Journal of Chemistry,* 1: 53-78.

Pearson K (1896) Mathematical contributions to the theory of Evolution, III. Regression, Heredity and Panmixia. *Philos Trans R Soc Lond* 187:253–318.

Rajan M.R. and Paneerselvam I. (2005). Evaluation of drinking water quality in Dindigul city, Tamil Nadu. *Indian J. Environ. Ecoplan.*3: 771-776.

Rajas K P., Sharmila M.G., Banu, G.K. and. Smila K. H. (2005). Physico-chemical characteristics of drinking water in selected areas of Namakkal town (Tamil Nadu), India. *Indian J. Environmental Protection.* 3: 789-792.

Shreya D. and Nag K.S. (2015). Application of multivariate statistical analysis concepts for assessment of hydro-geochemistry of groundwater- a study in Suri I and II blocks of Birbhum district, west Bengal, *India. Appl Water Sci.*DOI 10.1007/s13201-015-0299-6.

Shikha B., Patra B.A., Gupta N.C., Arora S., and Singh R. A. (2007). Assessment of Drinking Water Quality of Delhi, India. *In*:12th ISMAS-WS-2007, March 25-30, Cidade de Goa, Dona Paula, Goa.

Sinha A.K., Saxena S. and Sexena R. (2004). Water quality Index for Ram Ganga River water at Muradabad. *Pollut. Res.* 23: 527-531.

Shrivastava V.S. and Patil P.R. (2002) Tapti river water pollution by industrial wastes: a statistical approach. *Nat. Environ. Pollut Technol* 3:279–283

Tiwari T.N. and Manzor A. (1988).Water quality index for Indian Rivers. In ecology and pollution in Indian rivers (Ed: R.K. Trivedy) Ashish Publishing House, New Delhi, 271286.

Tiwari T.N., Das S. C. and Bose P.K. (1986). Water quality index for the river Jhelum in Kashmir and its seasonal variations. *Pollut. Res.* 5:1-5.

WHO (2011). Guideline for Drinking water quality, 4th Edn. World Health Organization, Geneva

Xiao-Yan S., Guo-xum Y., Li-min T., Yu-xiao H. and Zejun L. (2006). Study on mechanism of groundwater pollution due to applying sewage water for irrigation condition. *Journal of safety and Environment*. 1:321-324.

Zeng X. and Rasmussen T.C. (2005). Multivariate statistical characterization of water quality in Lake Lanier, Georgia, USA. *J Environ Qual* 34:1980–1991

Zaidi J. and Pal A. (2015). Influence of temperature on physico-chemical properties of freshwater ecosystem of Bundelkhand region of Uttar Pradesh, India. *Int. J. Curr. Res. Chem. Pharma. Sci*. 3:1–8.

Source of Support: None.
Conflict of interest: None. Declared.