GIAP Journals

Green Chemistry & Technology Letters
Vol 1, No 1, November 2015, pg 71-76
DoI: 10.18510/gctl.2015.1111

WATER QUALITY INDEX AND CORRELATION STUDY FOR THE ASSESSMENT OF GROUND WATER QUALITY OF ALLAHABAD CITY

Girdhari Lal Chaurasia, Santosh Bahadur Singh, Satpal Singh, Mahesh Kumar Gupta, Neelam Shukla, Praveen Kumar Tandon#
#Department of Chemistry, University of Allahabad, Allahabad, UP, India-211002,
E-mail: pktandon1@gmail.com

Article History: 12nd July, Revised on 15th November, Published on 05th January 2016

Abstract

Water, the Nectar of Life', is fundamental resource which is essential for the survival of different sectors, such as agricultural sector, industrial sector and small business units. In the absence of proper planning, urbanization and industrial/agricultural activities have adversely affected many regions around the world. This has led to indiscriminate actions, including dumping of wastes into the water and washing and bathing in open surface water bodies. In the present study groundwater samples from five sampling locations were collected and the analyses were done for nine physicochemical parameters. Water quality index assessment was carried out by using physicochemical analysis results. Water quality index of the sampling locations of Allahabad city has been divided into five categories. Good water quality index has been put into location 1 while locations 2, 3 and 4 indicate bad quality index. Very bad water quality index has been denoted in location 5. Correlation, the descriptive relationship among the physicochemical parameters, were also studied and it was found that the highly positively correlated values were among the parameters TDS vs EC (r=1.00), TS vs TSS (r=0.91), Temp vs TSS (r=0.87), Phosphate vs TSS (r=0.823) and highly negatively correlation was shown among TA vs Chloride. The result shows that the water quality of Allahabad city is not good and there is an urgent need for the preliminary treatment of water before it is used for the drinking purposes. There is also the need for the proper waste disposal and treatment system for the contaminants which seep in the groundwater and deteriorate groundwater quality. Awareness programmes should also be organized to educate the masses for the conservation and management of groundwater resources and the need to reduce of overuse and wastage of the groundwater resources should be emphasized. Sustainable water development in the city is needed to fulfill the demand of water for future.

Keywords: Correlation matrix, Groundwater, Industrialization, Physico-chemical analysis, Water quality index

INTRODUCTION

Water is the most precious resource of nature and it is the fundamental resource which is essential for different sectors, such as agricultural sector, industrial sector and all the small business units. Increase in human population and economic activities have tremendously increased the demand for large-scale suppliers of fresh water for various competing end users. The decline in the quality and quantity of surface water resources can be attributed to water pollution and the improper management of the resources [1].

Water quality monitoring has one of the highest priorities in environmental protection policy [2]. Many monitoring programs result in large and complicated data sets consisting of physical, chemical, biological and microbiological properties, which are difficult to analyze and interpret because of latent interrelationships among parameters and monitoring sites [3].

Statistical analysis of physicochemical parameters of water has been reported by various workers from India and abroad [4-8]. Linear correlation analysis study of drinking water quality data for Al-Mukalla city, Hadhramout, Yemen has shown that all the physicochemical parameters of drinking water are more or less correlated with each other [9]. Water quality index and ANN simulation method of River Ganga at Kolkata Region, India has been studied by Papita Das Saha et al., [10]. Water Quality Index (WQI) is a very useful and efficient method for assessing the suitability of water quality. It is also a very useful tool for communicating the information on overall quality of water to the concerned citizens and policy makers [11, 12]. WQI is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves [13]. Factors to be included in WQI model could vary depending upon the designated water uses and local preferences Water quality indices (WQIs) have been developed to integrate water quality variables[14,15 and 16]. A WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to managers and the public in a consistent manner [17].

The main objective of the study area

- Collection of groundwater samples in Allahabad city from the handpumps.
- Analysis of physicochemical parameters of groundwater samples collected from 5 different locations.
- To establish the relationship among the different parameters by correlation studies

GIAP Journals

Green Chemistry & Technology Letters
Vol 1, No 1, November 2015, pg 71-76
DoI: 10.18510/gctl.2015.1111

- Categorization of the water quality according to drinking purposes by the Assessment of water Quality index

MATERIAL & METHODS

The study area

The groundwater samples were collected from different locations in Allahabad city in the month of April 2014 which is shown below in location map figure 1:

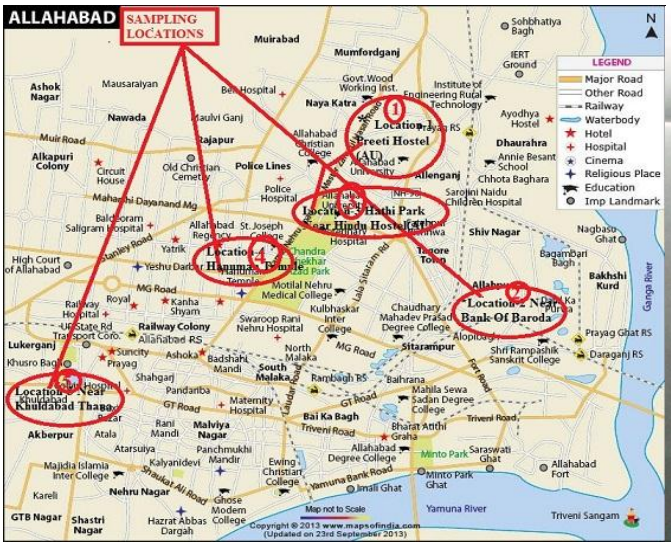

Figure 1: Location map sampling of Allahabad city (web source)

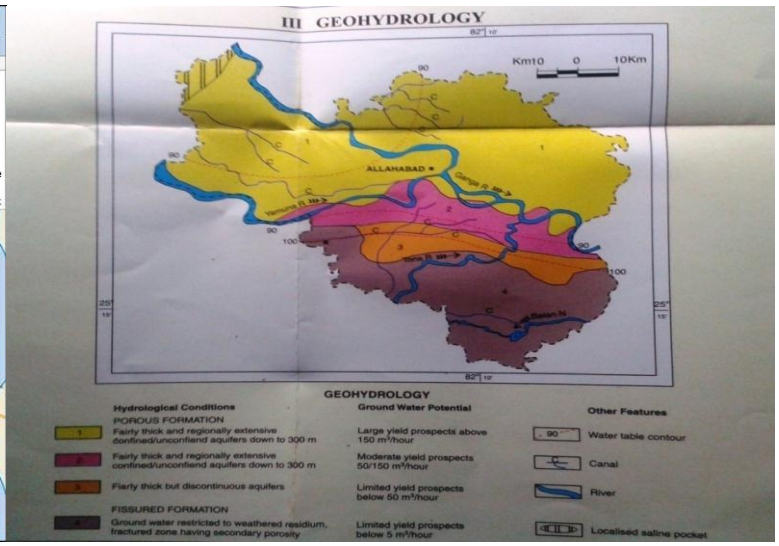

Figure 2: Map geo-hydrology of Allahabad (Source: District resource map provided by GSI, Lucknow)

Laboratory Analysis

The water samples were collected in duplicate from the Hand pump India Mark No.4 in one liter sampling bottles. The temperature was measured at the site by the Hg-thermometer and all other parameters were measured by following the APHA [18] standard procedure and were compared with the standards provided by BIS [19] & WHO [20]. The chemical analysis was done for the following nine parameters viz. temperature, PH, TDS, TSS, TS, total alkalinity, electrical conductivity, chloride and phosphate [Table-2].

Statistical Analysis

Statistical analyses were performed by xlstat 2015 statistical trial package & Microsoft excels 2003 & 2007 for performing the correlation analysis and water quality Index assessment.

Calculation of Water Quality Index

The calculation of WQI was made using weighed Arithmetic method in following steps [21] -Let water quality parameters and quality rating (qn) corresponding to n^{th} term parameter (a number reflecting relative value of this parameter) in the polluted water with respect to its standard permissible limits value. qn values are given by the relationship.

$$qn = 100 (Vn – Vi) / (Vs – Vi)$$

Where Vs-standard value, Vi-ideal value, in most cases Vi =0 except in certain parameters like pH, dissolved oxygen etc., calculation of quality rating for pH and DO (Vi was not zero).

$$Q\ PH = 100 (V\ PH – 7.0) / (8.5-7.0) \text{ and } Q\ DO = 100 (V\ DO – 14.6) / (5.0-14.6)$$

GIAP Journals

Green Chemistry & Technology Letters
Vol 1, No 1, November 2015, pg 71-76
DoI: 10.18510/gctl.2015.1111

Calculation of Unit Weight

The unit weight (Wn) to various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

$Wn = k / Sn$

Where Wn = unit weight for the nth parameter, Sn= standards permissible value for n^{th} parameter, k= proportionality constant

The unit weight (Wn) values in the present study are taken study are taken. [22]

Calculation of WQI

$WQI = \Sigma q_n Wn / \Sigma Wn$

Where n= i-n

The suitability of WQI values for human consumption is rated as follows [23]

0-25 Excellent, 26-50 = Good,

51-75 = Bad, 76-100 = Very bad and above it = Unfit

The WQI and overall WQI of all the samples taken were calculated according to the procedure explained above and are presented in Table-1.

Table 1: Calculations for Water Quality Index at site-1 Preeti Hostel (Allahabad University)

Parameter	Standard. Value (S_n)	Observed Value(Vn)	Unit wt (Wn)	Quality rating (Qn=Vn-Vi0/Sn-Vi0x100)	WQI= (Wn. Qn)
Temp	-	26	-	-	-
PH	7.0-8.5	5.74	0.3787	-84.00	-31.8108
TS	500(IS)	911	0.00643	182.2	1.171546
TSS	100 (BIS)	433	0.0322	433.0	13.9426
TDS	500 (WHO)	478	0.00643	95.6	0.614708
Conductivity	300 (BIS)	954	0.01073	318.0	3.41214
Total Alkalinity	200 (BIS)	308	0.0160955	154.0	2.478707
Chloride	250(BIS)	120	0.012876	48.0	0.618048
Phosphate	6 (BIS)	5	0.5365	83.33	44.706545

$WQI = \Sigma qn\ Wn / \Sigma Wn = 35.1333494/0.999956 = 35.13$

- The water quality indices of other locations were also calculated as per above index was calculated.

RESULTS & DISCUSSION

Table 2: Physico-chemical analysis of water samples of different sampling locations in Allahabad

Parameter	Unit	Standard	Preeti Hostel (AU)	Allahapur Near Bank of Baroda	Hathi Park(near Azad park, Hindu Hostel AU)	Civil Lines, Hanuman Mandir	Khuldabad (Near thana)
Temp	^{0}C	-	26	26	27	28	28
PH	-	7.0-8.5	5.74	6.2	5.89	5.45	6.96

Green Chemistry & Technology Letters
Vol 1, No 1, November 2015, pg 71-76
DoI: 10.18510/gctl.2015.1111

TS	mg/l	500 (BIS)	911	1126	983	1464	1103
TSS	mg/l	100 (BIS)	433	526	514	774	658
TDS	mg/l	500 (WHO)	478	600	469	690	445
EC	µs/Cm	300 BIS)	954	1204	918	1390	878
Total Alkalinity	mg/l	200 (BIS)	308	57.64	361.68	229.68	249.04
Chloride	mg/l	250 (BIS)	120	160	99.26	94.3	119.112
Phosphate	mg/l	6 (BIS)	5	7	5.8	8.5	10

Temperature & pH: In all the locations range of temperature was from 26-28 0C degree. Minimum temperature was at location 1& 2 (26 0C) and maximum at location- 4 & 5 (28 0C) (Table-2).The presence of hydrogen ion concentration was measured in terms of pH range. In our investigation the pH value of groundwater water ranged from 5.45 to 6.96 (Table-2) indicating that the nature of water is slightly acidic. The minimum pH was recorded at sample location– 4; Civil Lines, Hanuman Mandir, while the max at sampling location-5, which was below the permissible range.

TS, TSS &TDS: The TS value of groundwater water ranged from 911 mg/l to 1464 mg/l . The range of TSS varied from 433 to 774 mg/l in the study (Table-2) which was above the permissible limit prescribed by BIS and WHO standard at all the locations. The range of TDS varied from 445-690 mg/l in the study (Table-2). The min value recorded at sampling locations-5; Khuldabad (near Thana) and max value was recorded at location-4; Civil line Hanuman Mandir, which was within the permissible limit at 2 locations and were above the prescribed limit by BIS standard at 3 locations.

EC, Alkalinity, Chloride & Phosphate: The range of EC varied from 878-1390 µs/cm. (Table-2). The values of all locations are above the upper limit prescribed by BIS standard. Values of alkalinity ranged from 57.64-361.68 mg/l (Table-2). The values at locations-1, 3, 4 & 5 are above the max permissible limit prescribed by BIS. The chloride concentration in ground water was in the range of 94.3 to 160 mg/l (Table 2). All the observed values were within the permissible range. PO4 in the groundwater ranged from 5 to 8.5mg/l. The minimum phosphate concentrations were at the location-1 Preeti Hostel AU and maximum at location -4 civil lines (Table: 2). the results are within the permissible limit of BIS.

Water quality index assessment

Water quality index were calculated according to weighted Arithmetic mean method shown in the Table-3.

Table 3: Categorization of water quality at sampling locations on the basis of water quality index assessment

Preeti Hostel (Allahabad University)	Allahapur Bank of Baroda	Hathi Park (near Azad Park, Hindu Hostel AU)	Civil Lines, Hanuman Temple	Khuldabad (near thana)
35.13 (Good)	67.14 (Bad)	51.73 (Bad)	71.85 (Bad)	98.85 (Very Bad)

Correlation Matrix and their relationships

Correlation analysis is a preliminary descriptive technique to estimate the degree of association among the variables involved [24].Table-4 shows the correlation results as below:

Table 4: Karl Pearson correlation matrix of physicochemical parameters of groundwater Allahabad city

Variables	Temp.	pH	TS	TSS	TDS	EC	Total Alk.	Chloride	Phosphate
Temp	**1**	0.204	0.623	0.878	0.136	0.125	0.246	-0.643	0.804
PH		**1**	-0.273	0.008	-0.566	-0.564	-0.201	0.400	0.567
TS			**1**	**0.915**	0.854	0.850	-0.365	-0.262	0.611
TSS				**1**	0.571	0.565	-0.153	-0.419	0.823

TDS					**1**	**1.000**	-0.543	0.007	0.182
EC						**1**	-0.552	0.020	0.180
Total Alk.							**1**	-0.802	-0.292
Chloride								**1**	-0.069
Phosphate									**1**

Values in bold are different from 0 with a significance level alpha=0.05

CONCLUSION

Today the increased demand of water for different purposes such as drinking, industrial use, and agricultural sectors pressurized the extensive extraction of groundwater resources resulting in the lowering of the ground water level. These results in increased pollutants load of the sewage and solid waste which seepage into the groundwater and alter the water quality for drinking purposes. In our study we have used the physico-chemical, statistical analysis (correlation) & water quality index as informative tools to categorize the water as per drinking needs and found that the water quality of the sampling locations- 1is in Good category and the sampling location-2, 3 & 4 falls in the Bad category and the sampling location-5 is in the condition of very bad quality. Hence there is great need towards the awareness about the conservation and management of the groundwater quality & quantity and policy towards the reducing the overuse of the groundwater extraction. There is need to develop method for sustainable uses of water resource in different sectors. Today's the need of integrated methods for assessment tools and techniques such as Water footprint Assessment, water resource monitoring tools and techniques for effective water resource management.

FUTURE SCOPE OF WORK

The present work will be beneficial for the researchers and other workers who are engaged in water resources conservation, development and management. Statistical and physicochemical methods and other multidisciplinary techniques will be helpful before designing the sampling and analytical steps to find out the reliability of the results of the study.

ACKNOWLEDGEMENT

GLC acknowledge the University Grant Commission for providing financial assistance (JRF & SRF) and the Geological Survey of India, Northern Region Lucknow, for providing the Allahabad District Resource Map.

REFERENCES

1. Mustapha A, Nabegu AB, Surface water pollution source identification using principal component analysis and factor analysis in Getsi River, Kano, Nigeria. Austr J Basic ApplSci Vol (5), (2011), 1507-1512.
2. H. Boyacioglu,"Surface water quality assessment using factor analysis", Water SA Vol. (32), No (3), July (2006),323-344.
3. Huang Jinliang, Ho Manhim Pengfei Du, Assessment of temporal and spatial variation of coastal water quality and source identification along Macau peninsula Stoch. Environ Res Risk Assess, Vol (25), (2011), 353–361.
4. Dewangan S, Vaishnav M M and Chandrakar P L and Korba C G, Rasayan J Chem, Vol(3), No(4), (2010) 710-720.
5. Joshi Dhirendra Mohan, Bhandri Narendra Singh, Kumar Alok and Agrawal Namita , Rasayan J Chem., , Vol(2),No(3), (2009), 579-587.
6. Navneet Kumar and Sinha D K, Int J Environ Sci., vol (1) , No(2), (2010), 253-259.
7. Suhaimi – Othaman M, Ahmad A, Mushrifah I and Lim E C, Seasonal influence on water quality and heavy metal concentration in Tasik Chini, Peninsular Malaysia, Proceedings of Taal 2007: The 12th World Lake conference(2007),300-303.
8. Vassilis Z Antonopoulos, Dimitris M Papamichail and Konstantina A Mitsiou, Hydrology and Earth System Sciences, Vol (5), No (4), (2001), 679-691.

9. Sami G Daraigan, Ahmed S Wahdain, Ahmed S BaMosa and Manal H Obid, Int J Environ Sci., Vol(1), No(7), (2011),1692-1701.

10. Papita Das Saha, Sengupta R, Jhuma Saha and Banerjee P K, Arch Environ Sci., 2012, Vol (6), (2012) 34-41.

11. Asadi, S.S., Vuppala, P., Anji, R.M, Remote sensing and GIS techniques for evaluation of groundwater quality in municipalcorporation of Hyderabad (Zone-V), Indi. Int. J. Environ. Res. Public Health, Vol (4), No (1),(2007),45-52.

12. Buchanan,S. Triantafilis, J. Mapping water table depth using geophysical and environmental variables,Groundwater,Vol(47),No(1),(2009),80-96.

13. Miller, W. W, Joung, H. M, Mahannah, C. N. and Garrett, J. R.Identification of water quality differences Nevada through index application. J. Environmental Quality, Vol (15), No (3),(1986), 265-272.

14. Cude C. Oregon water quality index: A tool for evaluating water quality management effectiveness. Journal of the American Water Resources Association, Vol (37), No (1), (2001), 125–137.

15. Liou, S, Lo, S, and Wang, S.A generalized water quality index for Taiwan. Environmental Monitoring and Assessment, Vol (96), No (1-3), (2004) 35–52.

16. Said, A, Stevens, D, and Selke, G.An innovative index for evaluating water quality in streams. Environmental Management, Vol (34), No (3), (2004), 406–414.

17. Saksena D.N, Garg R.K, and Rao R.J. Water quality and pollution status of Chambal river in National Chambal sanctuary, Madhya Pradesh. J. Environ. Biol., Vol (29), No (5), (2008), 701-710.

18. APHA.Standard methods for the examination of water and waste water. American Public Health Association Washington D.C. (2005).

19. Bureau of Indian Standards, Indian Standards (IS: 10500) Drinking Water Specification: New Delhi (2004).

20. World Health Organization; Guidelines for drinking Water Quality, Recommendation 2ndEdition; Geneva, WHO Vol.1, (2008).

21. Brown R.M, Mccleiland N.J, Deiniger R.A, Oconnor M.F.A.Water quality index- crossing the physical barrier Proc. Int. Conf. on water pollution research, Jerusalem, Vol(6), (1972), 787-797.

22. Krishnan J.S.R, Rambabu K, Rambabu C. Studies on water quality parameters of bore waters of Reddigudum Mandal. Ind. J. Env. Proct. Vol (16), No (4), (1995), 91-98.

23. Mishra P.C., and Patel R.K., Quality of drinking water in Rourkela, outside steel town ship. J. Env. Poll, Vol (8), No (920), (2001), 165-169.

24. Ahamed A Jafar and Loganathan K, Assessment and correlation analysis of surface and ground water of Amaravathi river basin-Karur, Tamilnadu, India, Journal of Chemical and Pharmaceutical Research,Vol(4), No(8), (2012), 3972-3983.