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Statistical method (Paired t-test) of application to evaluate seasonal variation in concentration of pH in selected groundwater samples of Kolar District, Karnataka, India

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Abstract
Water is one of the most unusual natural compounds found on earth, and it is also one of the most important components of life. Presently many current environmental issues (Greenhouse effect, global warming, climate change, acid rain and ozone layer depletion), natural process, variation in geology and anthropocentric activities impose and induces groundwater quality deterioration. The present study is undertaken to analyze, assess and compare the different physico–chemical and biological parameters, mainly more emphasis (concentrated) on pH concentration in groundwater of Kolar District for the period of two years. Range of pH varies from organism to organism. The pH optimum for many bacteria ranges from 3-8, for yeast 3-6, for molds 3-7, for plants 5-6, for animals 5-6 and for human being 6.5-7.5. With regard to statistical analyses (paired t-test and Independent t- test) the pH concentration values were greater than the significance level, hence there was no significant difference in concentration of pH compared to two different seasons of the year 2014 and 2015.

Keywords: Groundwater, pH, seasonal variation, statistical analysis, paired t-test

1. Introduction
"For the group of water samples, a paired sample student t-test revealed that most of the parameters, including turbidity, TDS, conductivity, DO, BOD, nitrate, sulphate, iron content, *E. coli*, and faecal streptococci, had calculated values that were less than the table values (at $p<$ 0.05), indicating no significant seasonal variation. In contrast, other metrics like temperature, total suspended particles, pH, and total hardness had computed values that were greater than the table values (at $p>$ 0.05)", indicating that there was a considerable seasonal change (Makwe and Chup, 2013) [3]. Indicators of the right relationship between the various properties of water include statistical measures like standard deviation, median, mean, regression analysis, and correlation coefficient. Because $p>0.05$, the Anova shows no statistically significant difference between the different blocks and months in the physical or chemical characteristics of the water quality (Nasim Ahmad Ansari, 2017) [9]. "Seven pairs of groundwater quality parameters-EC-TDS, EC-sodium, EC-chloride, TDS-sodium, TDS-chloride, pH-carbonate, and sodium-chloride"-were shown in correlation matrices to have a very strong linear connection during both seasons. The size of the link was, however, noticeably lower during the post-monsoon season than it was during the pre-monsoon season. According to the t-test results, there was a significant change in the mean concentrations of six parameters over a four-year period, including pH, sodium, calcium, bicarbonate, nitrate, and fluoride. However, during a four-year period, only nitrate demonstrated a discernible shift in the post-monsoon season. Additionally, according to WHO guidelines and USSL diagrams, the groundwater quality in the area is not deemed acceptable for irrigation use (Trupti Kamble *et al.*, 2016) [14].
By determining the correlation coefficients between various parameter pairs and using the t test to determine significance, statistical investigations have been conducted. The observed values of different physico-chemical parameters in water samples were contrasted with the suggested standard values by the WHO. It is discovered that there is a notable significant

positive link between sodium and hardness, EC, and sulphate and between "chloride and pH, Mg, Na, hardness, and total suspended solid".

The systematic study of paired t-test reveals that there was a considerable negative association between "potassium and turbidity, Cl-, EC, and hardness" (Narendra Singh Bhandari and Kapil Nayal, 2007) [8]. The systematic determination of the correlation coefficient (r) between several physicochemical characteristics made it possible to compare the water quality levels at various places and to recommend a particular location as needing treatment first (Shikha Saxena *et al*., 2016) [12]. The correlation study is used to confirm any relationships between the calculated values. Following sample analysis, a graphic link between key water quality metrics and pH was created to help comprehend how their amounts varied with pH. Groundwater should be properly treated to protect citizens from the harmful impacts of elevated toxic component concentrations (Karamat Mehmood *et al*., 2012) [6].

At different distance, water samples were collected from the different source points in and around the Karu Abattoir and employ them in to analysis process to identity the concentration level of different physico-chemical parameters including the pH, finally for statistical assessment t-test was used. The result reveled mean value of maximum of the parameters have their suggest values in the WHO requirements in each seasons (Edith Makwe and Clement Chup, 2013) [7]. As the proverb Knowledge is power, so a person who wants to apply a statistical method he/she must has adequate knowledge background thereby he/she compile the statistical data and monitor the pollution of ecosystem (Richard O. Gilbert, 1987) [10]. 5 different groundwater samples from three sites of Sanjaner Tehsil of Jaipur District, Rajasthan were collected and analyzed for different physic-chemical parameters including pH. The result was applied to statistical methods like ANOVA and t-test. It is suggesting that the water which were collected form that area was not potable and other use like industrial purpose. This information played important role to take essential action by government of local area (Hina Shahnawaz and Chandni Kriplani, 2018) [4]. Application of statistical (t-test) method will give ample and accurate calculation for concentration of different physio-chemical features of groundwater pollution (Chou CJ, 2004) [2]. Groundwater statistical tests can assist decision making, no matter how the challenge is defined (The interstate technology & regulatory council groundwater statistics and monitoring compliance team, 2013). The result obtained after application of statistical method helps us to better understanding of role of variability of pollutant on water quality thereby we can draw the conclusion perfectly (Roxy Peck *et al*., 2008) [11]. Water quality test was conducted to know the what is the concentration of pH level in Drina area; it is a border between Herzegovina, Serbia and Bosnia. Consistent with statistical facts processing that Drina water nice at all four control points permits for its exploitation (Igor Lescesen *et al*., 2015) [5].

Study area

"Kolar District, spread over 4,012 sq Km, has population of about 16.50 lakhs. 5 Taluks of Kolar District are Kolar, Bangarpet, Malur, Mulbagal and Srinivaspur. It is stretched between north latitude $12^{o}45^{l}\ 54^{ll}$ to east latitude $77^{0}50^{l}\ 29^{ll}$".

1798 villages are part of 156 gramme panchayats in the Kolar District. Agriculture, which is solely sustained by bore well water, is the peoples' primary activity. The region has a semiarid environment that is dry for agriculture and is characterized by tropical monsoons, scorching summers, and moderate winters. The research area has no significant sources of surface water, and bore wells (groundwater) constitute the primary supply of drinking water.

Materials and Methods

The parameters of groundwater, including chloride and other parameters, were analysed from a total of fifty groundwater samples that were taken seasonally from fifty distinct bore wells spread throughout the five different talukas of Kolar District.

"One of the most significant and common tests in water quality is pH measurement. Hydrogen ions play an essential role in virtually every step of the water supply and waste water treatment process, including acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control". pH or hydrogen ion activity at a specific temperature serve as indicators of how acidic or basic a solution is. By using an electrometrical approach, pH is calculated (APHA, 2000) [1]. Within two hours of sample collection, a digital pH metre (electrometric method) was used in the lab to assess the sample's pH.

The fundamental idea is that the activity of hydrogen ions is measured potentiometrically using a combination of glass and reference electrodes with temperature correction, which reacts only to hydrogen ions.

Results and Discussion

Table 1: Showing seasonally changes in the concentration of pH from different sources at study area Kolar District for the period pre and post monsoon season 2014 and 2015

Sl_No.	Monsoon season 2014			Monsoon season 2015		
	Pre	Post	% Change	Pre	Post	% Change
	March-May	October-December		March-May	October-December	
1.	6.58	6.98	6.1	7.10	7.20	1.4
2.	6.90	7.00	1.4	7.00	7.00	0.0
3.	6.90	7.10	2.9	7.00	7.40	5.7
4.	6.50	6.80	4.6	7.60	7.10	-6.6
5.	6.52	6.58	0.9	7.50	7.20	-4.0
6.	7.20	7.20	0.0	7.60	7.60	0.0
7.	6.89	7.00	1.6	7.50	7.10	-5.3
8.	8.40	8.60	2.4	7.10	8.00	12.7
9.	7.20	7.60	5.6	7.80	7.80	0.0
10.	7.85	7.87	0.3	7.70	7.10	-7.8
11.	7.88	7.80	-1.0	7.90	7.90	0.0
12.	7.90	7.80	-1.3	7.90	7.90	0.0

13.	7.50	7.10	-5.3	7.20	7.20	0.0
14.	7.50	7.60	1.3	7.80	7.80	0.0
15.	6.80	6.50	-4.4	6.90	6.50	-5.8
16.	7.20	7.40	2.8	7.60	7.90	3.9
17.	7.10	7.50	5.6	7.20	7.50	4.2
18.	7.80	7.60	-2.6	7.20	7.50	4.2
19.	6.89	6.91	0.3	7.50	8.00	6.7
20.	8.00	8.20	2.5	6.50	7.90	21.5
21.	6.90	6.90	0.0	7.10	7.00	-1.4
22.	7.50	6.80	-9.3	7.60	6.89	-9.3
23.	7.20	7.20	0.0	8.30	7.30	-12.0
24.	7.80	7.40	-5.1	8.00	7.50	-6.3
25.	7.21	7.51	4.2	8.00	8.00	0.0
26.	7.50	7.20	-4.0	7.60	7.10	-6.6
27.	7.89	7.74	-1.9	8.10	7.90	-2.5
28.	7.20	7.30	1.4	7.50	7.80	4.0
29.	7.50	7.30	-2.7	7.80	7.50	-3.8
30.	6.98	7.00	0.3	8.00	7.90	-1.3
31.	6.92	7.00	1.2	8.00	7.80	-2.5
32.	7.20	7.50	4.2	8.00	7.60	-5.0
33.	7.80	6.70	-14.1	6.80	6.80	0.0
34.	7.60	7.60	0.0	7.70	7.40	-3.9
35.	6.50	7.30	12.3	6.90	7.50	8.7
36.	7.20	7.40	2.8	7.80	7.30	-6.4
37.	7.10	7.20	1.4	7.80	7.40	-5.1
38.	7.80	7.80	0.0	8.00	7.70	-3.8
39.	7.52	7.52	0.0	7.60	7.30	-3.9
40.	6.90	6.90	0.0	7.80	7.50	-3.8
41.	7.10	7.40	4.2	7.20	7.30	1.4
42.	7.30	7.10	-2.7	7.00	7.40	5.7
43.	6.80	7.60	11.8	7.10	7.50	5.6
44.	6.60	6.98	5.8	6.90	7.30	5.8
45.	7.20	7.20	0.0	7.50	7.10	-5.3
46.	7.40	7.70	4.1	7.10	7.80	9.9
47.	7.30	7.30	0.0	7.30	8.60	17.8
48.	7.20	7.30	1.4	7.60	8.30	9.2
49.	7.40	7.50	1.4	7.20	8.10	12.5
50.	7.40	7.40	0.0	7.50	7.40	-1.3
Average	7.27	7.32		7.49	7.51	

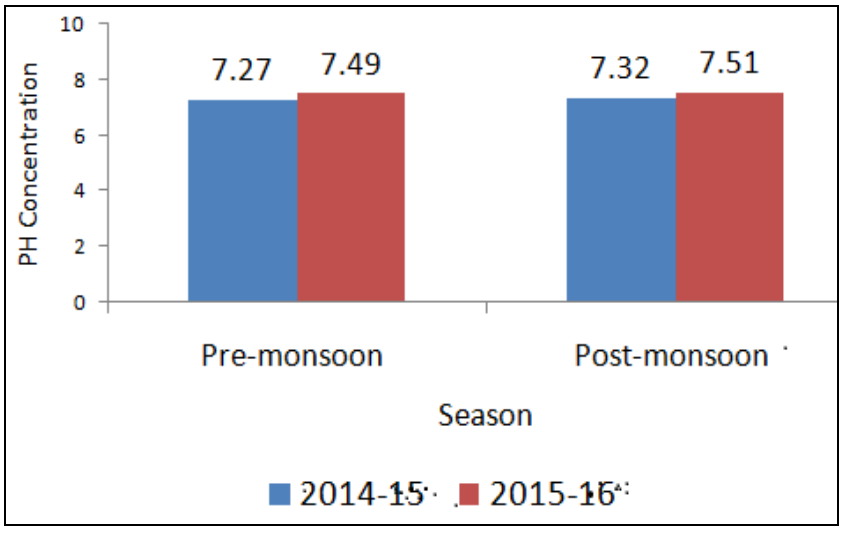

Fig 1: Average seasonal pH concentration in Kolar District – 2014 and 2015

Paired t-test analysis result for pH Concentration

A. Between pre-monsoon and post-monsoon season 2014:

Table 2: Paired samples t-test result of pH concentration for pre-monsoon and post-monsoon season during 2014

Variable	N	Mean	S.D	S.E	Correlation	Mean Difference	t-value	p – value
Pre-monsoon	50	7.27	0.43	0.061	0.716	-0.049	-1.103	0.275
Post-monsoon	50	7.32	0.40	0.056				

Table 3: Paired samples t-test result of pH concentration for pre-monsoon and post-monsoon season during 2015

Variable	N	Mean	S.D	S.E	Correlation	Mean Difference	t-value	p - value
Pre-monsoon	50	7.49	0.406	0.057	0.250	-0.023	-0.338	0.737
Post-monsoon	50	7.51	0.406	0.057				

It is emerged from the paired t-test of pre-m0nsoon and post-monsoon season during 2014 and 2015 are depicted in Table 2 and Table 3 that the p-value are 0.275 and 0.737 respectively which are greater than the significance level alpha of 0.05. Hence, "we accept null hypothesis and reject the alternative hypothesis". In other words, there is no significant difference in the mean score of pH concentration between pre-monsoon (mean = 7.27) and post-monsoon (mean = 7.32) season during 2014 and mean score (mean = 7.49) and post-monsoon (mean = 7.51) during 2015.

b. Between pr- monsoon (2014 & 2015) and post-monsoon (2014 & 2015)

Table 4: Independent t- test result of pH concentration for pre-monsoon (2014 & 2015) and post-monsoon (2014 & 2015) combined

Variable	N	Mean	S.D	S.E	Correlation	Mean Difference	t-value	p - value
Pre-monsoon (2014 -15 combined)	100	7.37	0.432	0.043	0.519	-0.036	-0.879	0.381
Post-0 monsoon (2014 -15 combined)	100	7.41	0.413	0.041				

It is emerged from the paired t-test of pH concentration for pre monsoon (2014 & 2015) and post monsoon (2014 & 2015) combined in Table 4 that the p-value is 0.381 which is greater than the significance level alpha of 0.05. Hence, "we accept null hypothesis and reject the alternative hypothesis". In other words, there is no significant difference in the mean score of pH concentration between pre-monsoon (2014-15 & 2015-16 combined) (mean = 7.37) and post-monsoon (2014 & 2015 combined) (mean = 7.41) season.

Conclusion

From paired samples t test result of pH concentration for pre and post monsoon season during 2014 and Paired Samples t-test result of P^H concentration for pre and post monsoon season during 2015, It is emerged that the p-value is are 0.275 and 0.737 respectively which are greater than the significance level alpha of 0.05. Hence, "we accept null hypothesis and reject the alternative hypothesis". In other words, there is no significant difference in the mean score of pH concentration between pre-monsoon (mean = 7.27) and post-monsoon (mean = 7.32) season during 2014 and mean score (mean = 7.49) and post monsoon (mean = 7.51) during 2015.

In independent t-test result of pH concentration for pre monsoon (2014 & 2015) and post monsoon (2014 & 2015) combined reveals that the p-value is 0.381 which is greater than the significance level alpha of 0.05. Hence, "we accept null hypothesis and reject the alternative hypothesis". In other words, there is no significant difference in the mean score of pH concentration between pre-monsoon (2014 & 2015 combined) (mean = 7.37) and post-monsoon (2014 & 2015 combined) (mean = 7.41) season.

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