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A statistical approach to multivariate analysis of drinking water quality in Kamrup district, Assam, India

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ABSTRACT

Drinking water quality with respect to content has been carried out Temperature, pH, Electrical conductivity, Total Solid (TS), Total Dissolved Solids(TDS), Total Suspended Solids(TSS), Turbidity, Dissolved Oxygen (DO), Total Hardness(TH), Calcium Hardness (CH), Magnesium Hardness(MH), Chloride (Cl), Sulphate(SO_4),Sodium (Na) and Potassium(K) in Kamrup district of Assam, India. Forty six different sampling stations were selected for the study. Statistical analysis of the data is presented to determine the distribution pattern, localization of data and other related information. Statistical observations imply non-uniform distribution of the studied parameters with a long asymmetric tail either on the right or left side of the median.

Key words: Drinking water, Kamrup district, Asymmetric Distribution, Skewness, Kurtosis,t-Test.

INTRODUCTION

Quality water is vital to the social, health and economic well- being of the prairies and its people. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes and oceans. Every effort should be made to achieve drinking water quality as safe as practicable. The lack of a source of clean drinking water is arising public health concern worldwide. Waterborne diseases are a consequence [1]. Rapid increases in population over the past century have aggravated the pressure on existing water resources. A critical step in assuring the quality of drinking water resources is to identify the cause of current or potential contamination problems.

The quality of potable drinking water has been a major issue in the developing nations for the last few decades [2]. Rapidly shrinking surface water resources due to over-exploitation and resulted contamination with several chemical and biological agents all over the globe has shifted tremendous pressure on the groundwater resources [3]. India is currently facing critical water

supply and drinking water quality problems. Water supplies in India are no longer unlimited. In many parts of the country, water supplies are threatened by contamination and future water supplies are uncertain [4]. There is growing shortage of usable water resources and it is going to be one of the major issues of the twenty first century. Human use of fresh water has registered a 35 fold increase in the last 300 years [5]. The health effects of unsafe potable water are most apparent in the developing countries, among the unfortunately communities that suffer from scarcity of the clean water resources[6]. In recent years, due to the increased availability of rapid and advanced testing and monitoring tools, remarkable progress has been made in generating vital data and developing a sound knowledge base in all fields of natural resources. Yet, regions like the northeastern part of India continue to face the daunting task of creating baseline data for the chronically data-poor water sector. The need for such data is apparent: despite the region's huge water resource potential, it still accounts for some of the most water-starved pockets of the country [7].

The present study was carried out to evaluate the status of the potable quality of the drinking water samples in Kamrup district, Assam, India. The samples were analyzed for water quality parameters viz., Temperature, pH, Electrical conductivity, Total Solid (TS), Total Dissolved Solids(TDS), Total Suspended Solids(TSS), Turbidity, Dissolved Oxygen (DO), Total Hardness(TH), Calcium Hardness (CH), Magnesium Hardness(MH), Chloride (Cl), Sulphate(SO_4),Sodium (Na) and Potassium(K).

Temperature influences physical, chemical and biological qualities of water. Increase in temperature above normal results in volatilization of trace compounds in water and may be responsible for imparting taste and odour. Disinfection of water is largely dependent on temperature and the bacterial survival is also influenced by it. Temperature variation may be one of the factors responsible for seasonal variation of coliform organisms in water bodies. High TDS value may be an indication of the presence of excessive concentration of some specific substance, which would make the water unsafe and aesthetically objectionable to the consumer.

Corrosion effects may become significant at a pH below 6.5 and scaling may become a problem at a pH above 8.5. Chloride content (WHO limit :250mg/L) above the permissible limit changes the taste of water which may become objectionable to the consumer. Calcium in water does not imparts any adverse health impact but can contribute towards hardness of water. Sodium is also not a health hazard for general population but it may affect the persons suffering from high blood pressure, kidney and cardiac problems if present in high concentration. Urinary excretes may fall due to reduced intake of potassium [8].

For the present study, 184 water samples were collected from forty six sampling locations (Table 1) (Fig.1) in Kamrup district spread over two seasons (Winter and Pre monsoon season and Monsoon and Post monsoon season) during 2006-2008. Kamrup district is the capital district of Assam. It is situated between 25.43 and 26.51 degree north latitude and between 90.36 and 92.12 degree east latitude. The greater parts of the district consists of wide plains, through the lower portion of which the mighty river Brahmaputra makes its way flowing a steady course from east to west. It covers an area of 4345 sq km. and receives an average rainfall of 1500 mm – 2600 mm. The region enjoys a climate of the sub tropical type with semi-dry summer & cold in winter.

Table 1 Water Sampling stations in the study area.

Sl. No.	Sampling stations	Source	Sl. No.	Sampling stations	Source
1	Naukata	TW	24	Lokhra	TW
2	Rangia	RW	25	Bezera	RW
3	Karara	TW	26	Noonmati	SW
4	Kendukona	TW	27	New Guwahati	TW
5	kamalpur	TW	28	Pan Bazar	SW
6	Puthimari	TW	29	Narengi	TW
7	Baihata Chariali	TW	30	Dispur	SW
8	Hajo	RW	31	Silpukhuri	RW
9	Changsari	RW	32	Bhangagarh	TW
10	North Guwahati	DTW	33	Kamakhya	DTW
11	Sualkuchi	TW	34	Gauhati University	TW
12	Palashbari	TW	35	Basistha	DTW
13	Chhaygaon	TW	36	Khanapara	TW
14	Sonapur	TW	37	Bhralumukh	DTW
15	Chandrapur	RW	38	Chandmari	TW
16	Khetri	DTW	39	Fancy Bazar	SW
17	Narengi	TW	40	Panjabari	RW
18	Boko	TW	41	Azara	TW
19	Dumunichowki	TW	42	Lankeswar	TW
20	Dimu	RW	43	Satmile	TW
21	Maligaon	TW	44	Jalukbari	TW
22	Boragaon	DTW	45	Satgaon	TW
23	Tetelia	TW	46	Panikhaiti	TW

MATERIALS AND METHODS

Sample Collection

Samples from supply water taps, tube wells, and deep tube wells were collected from the outlets after flushing water for 10–15 min in order to remove the stagnant water. Samples from the ring wells were collected using water sampler. All the samples collected in tight capped high quality sterilized polyethylene bottles were immediately transported to the laboratory under low temperature conditions in iceboxes. The samples were stored in the laboratory at 4 ◦C until processed/analyzed [9].

2.2 Physico chemical analysis

All physico chemical parameters were determined according to standard protocols [9]. Temperature, pH and conductivity were measured in the field using a thermometer with a precision of 0.1 ◦C, a calibrated portable pH-meter (Model Li 127, Elico,India) and EC-

meter(Elico). Turbidity was analyzed by nephelometric turbidimeter (model CL 52D,Elico,India) Among the major cations, sodium and potassium were analyzed by Flame Photometer (model CL-22D, Elico, India), major anions viz., Cl, was determined by argentometric titration method, SO4 was analyzed in triplicate by a UV–VIS spectrometer, (Shimadzu, 1240 model). DO, TH, Ca and Mg were estimated by titrimetric method [9]. The instruments were used in the limit of précised accuracy and chemicals used were of analytical grade.

Table2a Descriptive Statistics of elemental concentrations for the studied physico-chemical parameters.

Descriptive Statistics												
Statistic → / Parameters ↓	**Mean**	**Lower Bound**	**Upper Bound**	**Median**	**Variance**	**Std. Deviation**	**Min**	**Max**	**Range**	**Interquartile Range**	**Skewness**	**Kurtosis**
Temperature	21.8054	21.4396	22.1713	21	6.325	2.515	18	27	9	4.5	0.208	-1.273
PH	6.97	6.9195	7.0325	6.9	0.151	0.3885	6	7.9	1.9	0.4975	0.128	-0.367
EC	10.6601	9.536	11.7841	8.4	59.721	7.7279	1.6	82	80.4	8.325	4.523	38.533
TS	153.777	145.765	161.79	144	3034.61	55.0873	26	320	294	65.75	1.017	0.715
TDS	101.856	93.88	109.832	90	3006.98	54.8359	5	299	294	58.75	1.139	1.627
TSS	40.25	36.7242	43.7758	35	587.598	24.2404	5	130	125	25	1.483	2.705
Turbidity	2.062	1.9433	2.1806	1.9	0.666	0.8159	0.5	4.5	4	1.1	0.662	0.609
DO	6.0802	5.8838	6.2766	6.2	1.823	1.3502	2	9.3	7.3	1.61	-0.363	0.545
TH	108.963	98.7051	119.222	89	4974.07	70.5271	9	478	469	59.75	2.181	6.66
CaH	78.7052	70.0029	87.4076	63	3579.54	59.8292	4	435	431	49.8125	2.803	11.471
MgH	30.4438	27.7863	33.1013	27.63	333.82	18.2707	0.29	114	113.71	16	1.684	4.552
Chlorine	47.0837	41.9383	52.229	38.17	1251.38	35.3748	9.94	224.36	214.42	37	2.241	7.121
Sulphate	13.105	10.8118	15.3981	8.2	248.555	15.7656	0	91.05	91.05	14.1275	1.932	4.305
Sodium	32.9891	30.1106	35.8677	31.5	391.661	19.7904	0	91	91	25.75	0.54	0.21
Potassium	4.1957	2.6962	5.6951	1	106.278	10.3091	0	81	81	2	4.967	27.818

Table 2b Statistics showing percentiles of distribution of the studied physico-chemical parameters

	N		Percentiles		
	Valid	Missing	25	50	75
Temperature	184	0	19.5000	21.0000	24.0000
PH	184	0	6.7025	6.9000	7.2000
EC	184	0	5.9250	8.4000	14.2500
TS	184	0	110.0000	144.0000	175.7500
TDS	184	0	66.2500	90.0000	125.0000
TSS	184	0	25.0000	35.0000	50.0000
Turbidity	184	0	1.5000	1.9000	2.6000
DO	184	0	5.2900	6.2000	6.9000
TH	184	0	67.0000	89.0000	126.7500
CaH	184	0	42.1875	63.0000	92.0000
MgH	184	0	20.0000	27.6300	36.0000
Chlorine	184	0	23.0000	38.1700	60.0000
Sulphate	184	0	1.6225	8.2000	15.7500
Sodium	184	0	19.2500	31.5000	45.0000
Potassium	184	0	1.0000	1.0000	3.0000

2.3 Statistical Analysis

In this study, the tools used for data analysis are mainly experimental, aimed at defining possible relationships, trends, or interactions among the measured variables of interest. Descriptive statistics in the forms of mean, variance (V), standard deviation (SD), standard error (SE), median, range of variation, and percentile at 95%, 75% and 25% (P95%, P75%, P25%) are calculated and summarized in tabular form (Table 2a,&2b). The correlation analysis was

performed for measured parameters to determine the relationship between these variables (Table 3). Univariate statistics were used to test distribution normality for each parameter. *t*-Test is done under null hypothesis (H0) by taking the assumption that the experimental data are consistent with the mean rating given by WHO (Table4). SPSS® statistical package (Window Version10.0) was used for data analysis. All statements reported in this study are at the $P < 0.05$ levels.

Table3 Correlations status for the studied physico-chemical parameters

Pearson Correlation	Temp.	pH	EC	T S	TDS	TSS	Turbidity	DO	TH	Ca H	Mg H	Cl	SO4	Na	K
Temp.	1.000	-.022	-.070	.210**	-.023	-.060	.010	-.227**	.033	.002	.132	.018	.025	-.033	.062
pH		1.000	-.076	-.138	-.127	-.022	-.039	.204**	.084	.051	.156*	.055	-.130	.041	-.004
EC			1.000	.086	.061	.050	.053	-.031	.041	.035	.064	.273**	.212**	.206**	.107
TS				1.000	.706**	.295**	-.001	-.119	-.004	-.018	.044	-.007	.036	-.025	.067
TDS					1.000	-.014	.008	-.023	-.038	-.059	.015	-.021	-.033	-.039	.088
TSS						1.000	-.003	.042	.210**	.208**	.133	.115	.114	-.004	-.149*
Turbidity							1.000	-.020	.008	.013	-.005	-.058	.102	.102	-.114
DO								1.000	-.025	-.011	-.042	-.050	-.059	.135	-.043
TH									1.000	.972**	.665**	.334**	.141	.091	.043
Ca H										1.000	.477**	.337**	.201**	.090	.025
Mg H											1.000	.177*	-.102	.082	.085
Cl^-												1.000	.427**	.287**	.179*
$SO4^{--}$													1.000	.049	.219**
Na^+														1.000	.117
K^+															1.000

*** Correlation is significant at the 0.01 level (2-tailed).* * Correlation is significant at the 0.05 level (2-tailed).*

RESULTS AND DISCUSSION

To look into the seasonal variations and distribution pattern of all the physico-chemical parameters in groundwater, data were exposed to several statistical treatments. Descriptive statistics based on normal distribution has been shown in Table 2a & Table 2b. Correlation analyses were performed by Pearson's correlation and are presented in Table 3.

In the present study the pH values of all the samples are found within the prescribed limit except in sampling point 25 (Bezera). The values ranged from 6.25 to 7.4; the variation of pH is narrow and in general, the pH is towards the alkaline side. The general appearance of the collected samples of water was seen to be colorless having some odour in some cases. Most of these were seen to have clear appearance. The conductance of water in the study area have values greater than the maximum permissible limit (0.3 mmho cm-1) of USPH and indicates that water is markedly polluted with its reference. Ideally drinking water should have a turbidity of <1 NTU for aesthetic quality as well as for efficient disinfection. But the turbidity value was found to range between 0.5 – 4.5 NTU. Chloride and sulphate contents above the permissible limits can cause serious health problems to the consumer. Their concentrations in water under study are within the approved WHO guide line values for safe drinking water and no fixed trend of variation among the sampling stations could be ascertained. Total hardness lied between 9 to 478 mg/l. Calcium concentration was found to range between 4 to 435 mg/l while magnesium concentration lied between 0.29 to 114 mg/l. Calcium concentration exceeded permissible WHO standard (75mg/l) almost in 60 water samples.

The present study did not show any high value of sodium and potassium concentration. Potassium do not have any harmful effects on humans. However because of reduced potassium intake, urinary excretes may fall [8]. The rest of all the investigated parameters were found to be within the permissible range suggested by WHO and ICMR.

Statistical analysis of the present investigated data indicates off normal distribution of the studied parameters. This is evident from the difference between mean and median values, positive skewness and the width of the third quartile, which is greater than the first and second quartile.

Flat distribution for the observed parameters in the area is also indicated by negative kurtosis value(Table2a). A positive and significant correlation has been observed between temperature and total solid , P^h with dissolved oxygen and magnesium, EC with chlorine, sulphate and sodium, total solid with TDS and TSS,TSS with TH and Ca, Potassium with chlorine and sulphate concentration in the study area. A negative but significant correlation exists between temperature and DO and TSS and potassium.

By comparing calculated | t | value with tabulated t at 5% probability level of significance, we may either reject or accept our null hypothesis H0. The statistical values show that all of the studied water quality parameters are significant implying that the null hypothesis may be rejected. The calculated confidential limit will give the range within which the unknown value of the parameter is expected to lie (Table 4).

Table4 Results of One-Sample t-Test

Test Value = 0						
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Temperature	117.606	183	.000	21.8054	21.4396	22.1713
PH	243.582	183	.000	6.9760	6.9195	7.0325
EC	18.711	183	.000	10.6601	9.5360	11.7841
TS	37.866	183	.000	153.7772	145.7646	161.7898
TDS	25.196	183	.000	101.8560	93.8800	109.8320
TSS	22.523	183	.000	40.2500	36.7242	43.7758
Turbidity	34.282	183	.000	2.0620	1.9433	2.1806
Dissolved Oxygen	61.084	183	.000	6.0802	5.8838	6.2766
Total Hardness	20.957	183	.000	108.9634	98.7051	119.2218
Calcium Hardness	17.844	183	.000	78.7053	70.0029	87.4076
Magnesium Hardness	22.602	183	.000	30.4438	27.7863	33.1013
Chlorine	18.054	183	.000	47.0837	41.9383	52.2290
Sulphate	11.275	183	.000	13.1050	10.8118	15.3981
Sodium	22.611	183	.000	32.9891	30.1106	35.8677
Potassium	5.521	183	.000	4.1957	2.6962	5.6951

CONCLUSION

The inherent quality of waters in Kamrup district of Assam, India, is low and a suitable socio-economic policy and environment to maintain and improve water quality is also lacking. Anthropogenic disturbances have had and continue to have an impact on the drinking water sources of the study area. Majority of the ground water sampled were found to be weakly to moderately mineralized with calcium, sodium and chloride ions. Physico chemical data indicate that intensive use of land for agriculture, construction, waste dumping and industrial activities

has impacted greatly on the quality of drinking water in the region. It is, therefore, immediately required that the water sources be properly protected from potential contaminants, and that appropriate treatment be selected for future use of water in the region.

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