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A detailed statistical study of drinking water with its permissible limit in Chakdaha area

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Abstract
Present study aimed to assess and compare the sample water quality with WHO standards and BIS drinking water standards in relation with its physico-chemical parameters in Chakdaha town area. Certain physical and chemical parameters like total dissolved solids (TDS), the amount of chloride, the amount of total acidity and the total hardness was examined to find out quality of sample water. Four sample were tested including the supply drinking water, deep ground water, mineral water etc. All the result also were statistically validated with the parameters like precision and robustness. The findings of the analysis was found to be quite informative for the daily consumers of the water and will provide sufficient scope for finding out the proper source of drinking water.

Keywords: BIS, WHO, TDS, Safe drinking water, hardness

Introduction
Water is one of the abundantly available substances in nature. It is an important and life sustaining drinks to human and is essential for the survival of all the organisms. Living organisms require large quantities of water for their sustenance. Several contributors are to be noted who have made achievement in the field of hydrobiology in India and abroad. Water is most vital liquid for maintaining the life on the earth. About 97% water is exists in oceans that is not suitable for drinking and only 3% is fresh water wherein 2.97% is comprised by glaciers and ice caps and remaining little portion of 0.3% is available as a surface and ground water for human use [1]. Some of the important and recent contributors are [2-7] who have studied the physico-chemical parameters of the various water bodies.
It is therefore necessary to determine the certain physical and chemical parameters like total dissolved solids (TDS), the amount of chloride, the amount of total acidity and the total hardness to find out quality of ground water. The findings of the analysis will prove to be quite informative, to the daily consumers of the water.

Total dissolved solids (TDS)
Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. These minerals produced un-wanted taste and diluted colour in appearance of water. There is no agreement have been developed on negative or positive effects of water that exceeds the WHO standard limit of 1,000 ppm. Total dissolved solids (TDS) in drinking water is originates many ways from sewage to urban industrial wastewater etc. Therefore, TDS test is considered a sign to determine the general quality of the water [8]. The BIS (1991) has set desirable limit of TDS value to be 500 mg/l in potable water. However the permissible limit is 2000 mg/l in the absence of any alternative source in water. According to WHO (1993), the standard permissible limit for TDS is 1000 mg/l. Water at a TDS level of above 500 mg/l is unsuitable for flora and tastes unpleasant to drink [9].Total Dissolved Solids (TDS) correlates positively with conductivity and affects pH. The higher the TDS, the higher the conductivity and the lower the pH, towards acidity. The presence of dissolved solids in water may affect its taste. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste [10]. An isolated report, a summary of Russian studies available through the World Health Organization, has recommended that fluid and electrolytes are better replaced with water containing a minimum of 100mg/L of TDS. Although If homeostasis is not maintained because of major diet deficiencies, disease, or hormonal dysfunction, Consuming low TDS

water would be a minor (if any) factor in any observed symptoms [11].

Again the possible adverse consequences of low mineral content water consumption are discussed in the following categories:

a. Direct effects on the intestinal mucous membrane, metabolism and mineral homeostasis or other body functions.
b. Little or no intake of calcium and magnesium from low-mineral water.
c. Low intake of other essential elements and microelements.
d. Loss of calcium, magnesium and other essential elements in prepared food.
e. Possible increased dietary intake of toxic metals [12-40].

The amount of chloride

Usually, chloride concentrations in excess of about 250 mg/Litre can give rise to detectable taste in water, but the threshold depends upon the associated cations, a typical example being Sodium. The presence of sodium in drinking water is of significant health concerns. Therefore, the US Environmental Protection Agency (EPA) now requires drinking water to be monitored for sodium and public water suppliers are directed to report local health authorities any concentration above 250 mg/l. Chlorides in drinking water usually create taste and odour problems at concentrations exceeding 250 mg/l [41-42]. Although excessive intake of drinking-water containing sodium chloride at concentration above 250mg/l has been reported to produce hypertension [43]. This effect is believed to be related to the sodium ion concentration. Consumers may become accustomed to concentrations in excess of 250mg/l.

Chloride toxicity has not been observed in humans except in the special case of impaired sodium chloride metabolism, e.g. in congestive heart failure [44]. According to WHO standards concentration of chloride should not exceed 250 mg/l [1].

The amount of total acidity/alkalinity

The pH level of your drinking water reflects how acidic it is. pH stands for 'potential hydrogen', referring to the amount of hydrogen mixed with the water. pH is measured on a scale that runs from 0 to 14. A measurement of seven is neutral, indicating there is no acid or alkalinity. A measurement below 7 indicates presence of acid and a measurement above 7 indicates alkalinity. The normal range for pH in drinking water as per Indian Standard is between 6.5 and 8.5. The WHO and BIS (Bureau of Indian Standards) recommendation of pH is also 6.5- 8.5[9]. If total acidity is expressed in terms of calcium carbonate the value should lies in between 200-600 mg/l.

The total hardness

Hard water is characterized with high mineral contents that are usually not harmful for humans. It is often measured as calcium carbonate ($CaCO_3$) because it consist mainly calcium and carbonates the most dissolved ions in hard water**.** According to World Health Organization (WHO) hardness of water should be 500 mg/l. The standard permissible limit of total hardness value of drinking water set by BIS (1991) is 300 mg/l. Excessive hardness can cause skin irritation, kidney stone formation, hair loss etc. [1].

Fig 1: Constituents responsible for adverse effect of water

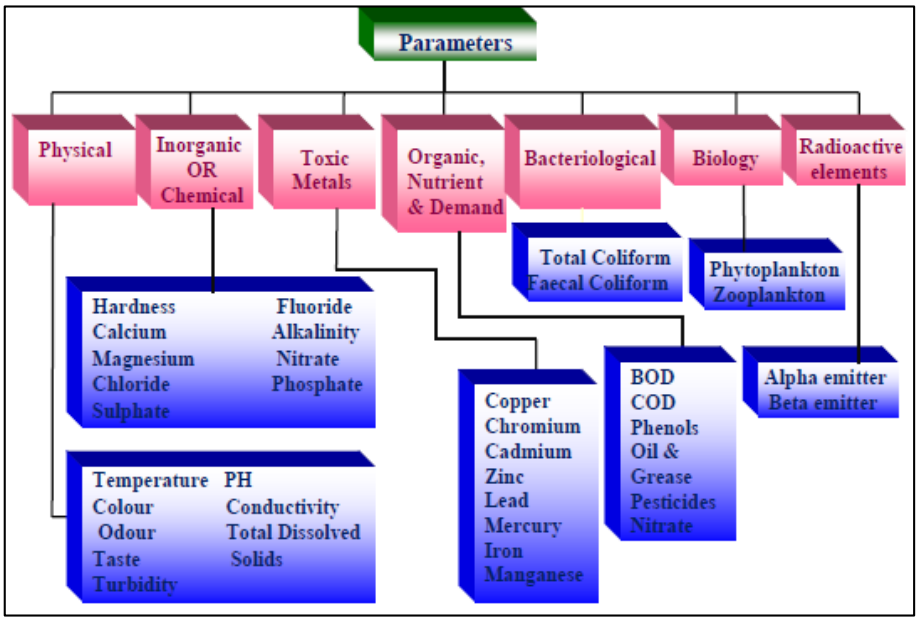

Fig 2: Parameters of water quality assessment

Estimation of validation parameters

Validation Parameters – Assays

USP General Chapter 1225, as well as the ICH Guideline for Industry (Text on Analytical Procedures), provide cursory descriptions of typical validation parameters, how they are determined, and which subset of each parameter is required to demonstrate validity, based on the method's intended use. For example, it would be inappropriate to determine limits of detection or quantisation for an active ingredient using an assay method intended for finished product release. However, if the method was intended to detect trace quantities of the active ingredient for purposes of a cleaning validation study, then knowledge of the detection and quantification limits are appropriate and necessary. For this reason, validation of each assay or test method should be performed on a case-by-case basis, to ensure that the parameters are appropriate for the method's intended use. This is even more important when validating stability indicating assay methods, because these validations are more complex - for example, they may require forced degradation, samples spiked with known degrades, literature searches, etc.

Some of the parameters are:

Precision

Precision is the measurement of how close the data values to each other for a number of measurements under the same analytical conditions. Precision may be considered at three levels according to ICH.

Repeatability

System Precision

Precision under same operative conditions (within a laboratory over a short period of time using the same analyst with the same equipment) was determined. Mean, SD and % RSD were calculated from data. The system precision is checked by using standard chemical substance to ensure that the analytical system is working properly. In this retention time and area of six determinations is measured and % RSD should be calculated.

Acceptance criteria: % RSD should be in between 98%-102%.

Method Precision

In method precision, a homogenous sample of single batch should be analysed 6 times. This indicates whether a method is giving consistent results for a single batch. In this analysis the sample has been analysed six times with the calculation of % RSD.

Acceptance criteria: % RSD should be in between 98%-102%.

Intermediate Precision (Ruggedness)

Precision under different laboratory conditions (within-laboratory variation, as on different days, or with different analysts, or equipment within the same laboratory) has been carried out.

Acceptance criteria: % RSD should be in between 98%-102%.

Robustness

Here the closeness of the values are seen in small changes of different parameters like solvent, temperature, pH etc. Here the mean, SD, % RSD is calculated.

Acceptance criteria: % RSD should be in between 98%-102%.

Reproducibility

Precision between laboratories/intermediate precision can be considered during the standardization of a procedure before it is submitted to the pharmacopoeia. A simple logic behind this parameter was some degree of inconsistency (Occurrence of random error) was allowed for every analytical measurement. But, the extent depends on steps involved (Weighing, dilution etc.), technique used in other expected variables (Stability) and intended use of the procedure [45].

Material and Methods

Materials

Sodium hydroxide, sodium chloride and silver nitrate were purchased from Merck India private limited. Na-EDTA was purchased from Loba Chem Pvt. Ltd.

Estimated water sample
Sample 1: Candle filter (Non-electrically filtered) water
Sample 2: Supply drinking Water
Sample 3: Deep ground water source.
Sample 4: Packaged mineral water

Method

1. Determination of the amount of total dissolved solids (TDS) in the sample of water

A Systronics model 306 Conductivity Meter with Conductivity Cell was used to measure the conductance reading. Conductance reading was noted which having the unit called Siemens. From that reading conductivity was measured with the help of cell constant value and temperature correction (Beyond 25^0 C). TDS was measured by multiplying the conductivity value with correlation factor (K). Conductivity meter was calibrated by using 0.01M KCl solution as the cell constant value was observed in the instrument during the process.

Calculation: Conductivity = Conductance (Observed value) X Cell Constant X Correction Factor (temp.). TDS = Conductivity X Correlation factor (K)

Table 1: Correlation of Conductivity and TDS in various type of water [46-48].

Conductivity at 25 ^{0}C	Ratio of TDS/Conductivity
Natural water for irrigation	0.55 - 0.75
Natural water, Conductivity = 500 − 3,000 µS⁄cm	0.55 – 0.75
Distillate water, Conductivity = 1 – 10 µS⁄cm	0.5
Freshwater, Conductivity = 300 – 800 µS⁄cm	0.55
Seawater, Conductivity = 45,000 − 60,000 µS⁄cm	0.7
Brine water, EC = 65,000 − 85,000 µS⁄cm	0.75

2. Determination of the amount of chloride in the sample of water

Soluble chlorides was determined by titrating then against silver nitrate solution using potassium chromate as an indicator.

3. Determination of the amount of total acidity/alkalinity in the sample of water

50 ml. of the sample water was pipette out in a clean dry conical flask with the addition of 1 – 2 drops of the indicator. Titration was carried out rapidly against the 0.02 M NaOH solution from the burette with the stirring gently till a faint permanent pink colour appeared. The process was repeated several times with 50 ml. of sample water each time till a constant burette reading is obtained.

4. Determination of the amount of total hardness (Permanent & Temporary) of the sample of water

50 ml. of sample water was pipette out in a dry clean conical flask. 5 ml. of the buffer solution was added with five drops of indicator into it. Then titration was carried out against the standardized EDTA solution from the burette till the red colour changes to the permanent purple blue.

Calculation: 1 ml. 0.01 M EDTA = 1 mg. Of $CaCO_3$ = 0.001 gm of $CaCO_3$
Constant reading * 106 * 0.001 * ppm$CaCO_3$/50 ml. Total hardness was expressed in terms of $CaCO_3$.

Result and Discussion

Table 2: Sample 1 analysis

Statistical Parameter	Water Quality Parameter	Result
Precision	TDS Count	RSD = 1.026439. as the RSD value is within range the result is precised with TDS count
	Amount of Chloride	RSD = 1.004825. As the RSD value is within range the result is precised amount of chloride wise.
	Amount of Total Acidity	RSD = 2.938157. as the RSD value is out of range the result is not precised amount of total acidity wise.
	Amount of Total Hardness	RSD = 1.072879. as the RSD value is out of range the result is not precised amount of total hardness wise.
Robustness	TDS Count	RSD = 1.013435. as the RSD value is within range the result is robust temp. variation wise.
	Amount of Chloride	RSD =1.009339. as the RSD value is within range the result is robust temp. variation wise. RSD = 1.181554. As the RSD value is out of range the result is not robust apparatus variation wise.
	Amount of Total Acidity	RSD = 1.179996. as the RSD value is out of range the result is not robust with temp. variation wise. RSD = 1.146702. as the RSD value is out of range the result is not robust apparatus variation wise.
	Total Hardness	RSD = 1.06589. as the RSD value is out of range the result is not robust temp. variation wise. RSD = 1.012326. As the RSD came within limit the result is apparatus wise robust.

Table 3: Sample 2 analysis

Statistical Parameter	Water Quality Parameter	Result
Precision	TDS Count	RSD = 1.016995. As the RSD came within limit the result is precised TDS count wise
	Amount of Chloride	RSD = 0.987. As the RSD came within limit the result is precised amount of chloride wise
	Amount of Total Acidity	RSD = 1.017879. As the RSD came within limit the result is precised amount of total acidity wise
	Amount of Total Hardness	RSD = 1.180093. As the RSD came out of the limit the result is not precised amount of total hardness wise.
Robustness	TDS Count	RSD = 4.151489. As the RSD came out of range the result is not robust temperature wise
	Amount of Chloride	RSD =1.029005. As the RSD came within limit the result is robust temperature wise RSD = 1.097992. As the RSD came out of the limit the result is not robust apparatus wise
	Amount of Total Acidity	RSD = 1.011955. As the RSD came within limit the result is robust temperature wise RSD = 1.146702. As the RSD value is out of range the result is not robust apparatus variation wise.
	Total Hardness	RSD = 1.080329 As the RSD came out of range the result is not robust temperature wise RSD = 0.995402. As the RSD came within limit the result is apparatus wise robust

Table 4: Sample 3 analysis

Statistical parameter	Water quality parameter	Result
Precision	TDS Count	RSD = 1.010704. As the RSD value is within range the result is precised with TDS count
	Amount of Chloride	RSD = 1.016296. As the RSD value is within range the result is precised amount of chloride wise.
	Amount of Total Acidity	RSD = 1.100533. As the RSD value is out of range the result is not precised amount of total acidity wise.
	Amount of Total Hardness	RSD = 1.011556. As the RSD came within limit the result is precised amount of total hardness wise.
Robustness	TDS Count	RSD = 2.262269. As the RSD value is out of range the result is not robust temp. variation wise.
	Amount of Chloride	RSD =1.052655. As the RSD came out of the range the result is not robust temp. variation wise. RSD = 0.994903. As the RSD came within the range the result is robust apparatus variation wise.
	Amount of Total Acidity	RSD = 1.022896. As the RSD came with in the range the result is robust temp. variation wise RSD = 1.08861. As the RSD came out of range the result is not robust apparatus variation wise
	Total Hardness	RSD = 1.028099. As the RSD came with in the range the result is robust temp. variation wise. RSD = 1.065978. As the RSD came out of range the result is not robust apparatus variation wise.

Table 5: Sample 4 analysis

Statistical Parameter	Water Quality Parameter	Result
Precision	TDS Count	RSD = 0.994362. As the RSD value is within range the result is precised with TDS count
	Amount of Chloride	RSD = 1.069207. As the RSD value is out of range the result is not precised amount of chloride wise
	Amount of Total Acidity	RSD = 1.009489. As the RSD value is within the range the result is precised amount of total acidity wise.
	Amount of Total Hardness	RSD = 1.074062. As the RSD value is out of range the result is not precised amount of total hardness wise
Robustness	TDS Count	RSD = 3.163006. As the RSD value is out of range the result is not robust temp. variation wise.
	Amount of Chloride	RSD =1.021864. As the RSD value is within the range the result is robust temp. variation wise RSD = 0.978217. As the RSD came within the range the result is robust apparatus variation wise.
	Amount of Total Acidity	RSD = 1.013. As the RSD came with in the range the result is robust temp. variation wise RSD = 1.03146. As the RSD came out of range the result is not robust apparatus variation wise
	Total Hardness	RSD = 1.000372. As the RSD came with in the range the result is robust temp. variation wise. RSD = 1.023302. As the RSD value is within range the result is robust apparatus variation wise

Table 6: Comprehensive result of analysis

Sample No.	Water Quality Parameter (Average Value) (Precision Result)	Result (Quality wise)
Sample 1 Candle filter (Non-electrically filtered) water	TDS = 321.88 mg/l	Within range (Good)
	Chloride content = 68.4 mg/l	Within range (Low content majority wise).
	Acidity/Alkalinity = 3.59 mg/l	Within range (Very low in content Majority wise)
	Total Hardness = 226.06 mg/l	Within range (Satisfy both WHO and BIS limit)
Sample 2 Supply drinking Water	TDS = 484.94 mg/l	Within range (Good)
	Chloride content = 56.97 mg/l	Within range (Low content majority wise).
	Acidity/Alkalinity = 7.82 mg/l	Within range (Very low in content Majority wise)
	Total Hardness = 469.23 mg/l	Within range (Did not satisfy BIS limit but satisfy the WHO limit majorly)
Sample 3 Deep ground water source.	TDS = 587.28 mg/l	Within range (Between good and fair)
	Chloride content = 48.43 mg/l	Within range (Low content majority wise).
	Acidity/Alkalinity = 9.59 mg/l	Within range (Very low in content Majority wise)
	Total Hardness = 425.23 mg/l	Within range Within range (Did not satisfy BIS limit but satisfy the WHO limit majorly)
Sample 4 Packaged mineral water	TDS = 29.05 mg/l	Within range (Very low majority wise)
	Chloride content = 61.17 mg/l	Within range (Low content majority wise).
	Acidity/Alkalinity = 2.64 mg/l	Within range (Very low in content Majority wise)
	Total Hardness = 80.67 mg/l	Within range (Very low in range in respect to both WHO and BIS limit)

Conclusion

So it can be concluded from the above study that the statistically validated data between the four experimental sample of drinking water deep ground water and supply drinking water are not suitable hardness wise and also packaged mineral water is not suitable with the TDS content wise and also considering other parameters as discussed. So the best way to go forward will be to use candle filter water which is free from the technique like RO or UV which are daily used now a days. So some essential parameters that are there to be identified before taking the drinking water that is important for any biological system and the above concept can be further followed by anybody to establish the proper source for intake of water.

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