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Hydrogeochemical analysis and groundwater quality applications of chloride in and around Puzhal Lake, Tamil Nadu, India

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***Abstract*---**Groundwater contamination is a complicated and major issue by a chuge number of potential sources. India has a wide variety of *morphological, meteorological, morphological, geological, hydrological* and *hydrogeological conditions*. The assessment of water quality is essential for giving sufficient information on the ecological environmental surfaces. Urban aquifers have been detected as one of the primary sources of drinking water. Due to urban development, active industrialisation has made a negative impact on increasing the amount of chloride in groundwater. The current study introduced the effectiveness of geochemical characteristics of drinking water and rounded water. Fourteen samples have been collected from Tamil Nadu for analysis of the chloride. This study shows that the presence of excessive chloride in water reduces water's natural quality. The presence of excessive Cl ions in water increases the risk of health hazards. Implementation of Gibb's diagram, hydrochemical analysis and WQ analysis will be beneficial to determine the good category of water in Tamil Nadu.

***Keywords*---**Groundwater, Water Quality, WQI, hydrochemical, Chloride.

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Introduction

The groundwater chemistry is an influential factor, for the determination of irrigation, domestic and industrial purposes. Rapid industrialisation and urbanisation without following strict environmental norms is increasing harsh materials in the groundwater. Acquiring knowledge in hydrochemistry is important for accessing water quality. According to Kocour Kroupová *et al.* (2018), ***Chennai*** is known as the capital state of Tamil Nadu and it is the 4th largest metropolitan city in India, growing industrialisation and active urbanisation is accountable for increasing pollution in the groundwater. The humidity of Chennai is about ***6 to 84%***, and it has different geological formations (Ahmad *et al.* 2018). The geological formation is divided into three different sections, such as the ***tertiary sediments*** and ***consolidated round water, recent alluvium*** and ***arcane crystalline rocks*** to distinguish the hydrochemical properties of grounded water. It is essential to detect the thickness of alluvial for the determination of the harmful effects of chloride in the groundwater. According to the 2008 "***CGWB technical report***", the storability is between ***2.9×10^{-4} and 4.5×10^{-3}*** (Patel *et al.* 2019). This research article will determine the effectiveness of the hydrochemical analysis process and the harsh effects of chloride in groundwater.

1.1 Harmful effects of chloride in groundwater

Chloride is one of the harsh materials, which is present in groundwater, rainwater, wastewater and many others. Ward *et al.* (2018) stated that water is considered fresh water at < 500 mg/L of dissolved salts. Chloride ion has been detected as the most predominant natural element in software. There are different sources of chloride water, such as ***sedimentary leaching***, ***weathering, municipal*** and ***domestic effluents*** and ***rock and soils***. As per this journal, the basic range of chloride water is found between ***115.21 to 2,011.8 mg/L***. According to ***Indian Standard*** and ***World Health Organisation (WHO)***, the desired limit of chloride water is 250 mg/L. During this research study, it has been detected that the concentration of chloride in water has been exceeded in certain locations. As per this journal, due to the poor underground drainage system, the concentration rate of chloride has been exceeded. Papageorgiou *et al.* (2018) argued that, apart from chloride, there are many other harsh materials, which is accountable for making a negative impact on the ground water. Implementation of the geochemical analysis process is essential to detect the number of harsh materials. The number of harsh materials will be discussed in the following section.

Table 1: Statistics of physicochemical parameters

Parameters	Maximum	WHO	BIS
TDS (mg/l)	4,669	500	500
Cl (mg/l)	2,011.8	250	250

Mg^{2+} (mg/l)	141.6	50	30
Na^{+} (mg/l)	1,200	200	Null
TH (mg/l)	814.55	Null	Null
K^{+} (mg/l)	36	Null	Null

(Source: Alhadithi *et al.* 2018)

Identification of the maximum amount of harsh material is essential to erect the risk factors of the above-mentioned significant properties in the groundwater. The maximum value of different hash material has been introduced in this project. Implementation of geochemical processes is essential to detect the risk factors of these materials. The presence of chloride is accountable for different kinds of health hazards in the animal and human body. **Effectiveness of Ground Water Quality Index for accessing groundwater portability**

Demand for groundwater is increasing in India, due to the rapid growth of urbanisation, industrialisation and population. Fayaji *et al.* (2019) stated that improper waste disposal and overexploitation of groundwater is becoming affected. As per WHO, nearly ***80%*** of disease has been detected as a waterborne disease in human beings. Groundwater quality is dependent on different chemical, physical and biological characteristics of water. The use of the "***Geographic Information System (GIS)***" technique is essential to determine the quality of groundwater. Implementation of the weighted arithmetic calculation process is essential to implement the "***Water Quality Index (WQI)***" for the determination of the anthropogenic effects of key parameters, such as ***K, NA, Cl*** and many others. The use of the WQI is essential for the detection of the physicochemical parameters of groundwater. The equation of WQI will be mentioned in the following section

$$WI = wi\sum_{i¼1}^{n} wi$$

According to the above-mentioned equation,
W*i* has been detected as the relative weigh
why is the weight of each parameter
n= Parameter's number [Parameter determines the harsh material present in the ground water]
This paper has detected the equation of WQI to measure the hydrochemical properties of groundwater. For calculating the stage of WQI, it is essential to measure the value of every key parameter in water.

$$Sli = Wi \times qi$$
$$WQI = \sum SI$$

According to the above-mentioned equation, ***Sli*** has been determined by every parameter's sub-index, ***qi*** is used to measure the concentration of each parameter. (n) determines the parameter's number.

The above-mentioned equation helps to determine the presence of parameters in groundwater for reducing the negative impact of chlorinated water. As per the selected journal, WQ has been detected as one of the important tools for making comparisons of the water's quality. Alhadithi *et al.* (2018) counter argues that mineral interaction is accountable for influencing the hydrochemistry of groundwater. This research paper has focused on the dominant alkaline metal, which deteriorates the quality of water.

Method and Materials

The sample of groundwater has been collected from 14 wells of different geographic regions, the depth range of grounded water is from ***80 to 155m***. According to Olasoji *et al.* (2019), it is essential to measure ***electrical conductivity (EC)*** and **pH**. ***The acid titration method*** has been used for bicarbonate analysis of groundwater. In this process, ***$AgNO_3$*** has been used for the measurement of chloride concentration rate. Different tools are essential to each at the conclusion of this research study. A spectrophotometer tool has been used for the evaluation of this significant method for the determination of the risk factors of water. The "***American Public Health Association (APHA)***" taken the responsibility to suggest innovative analytic process for reducing the risk factors in groundwater. Measurement of the reproducibility of harsh material is essential for the identification of the future risk of groundwater. Implementation of this process is essential for the maintenance of ionic balance.

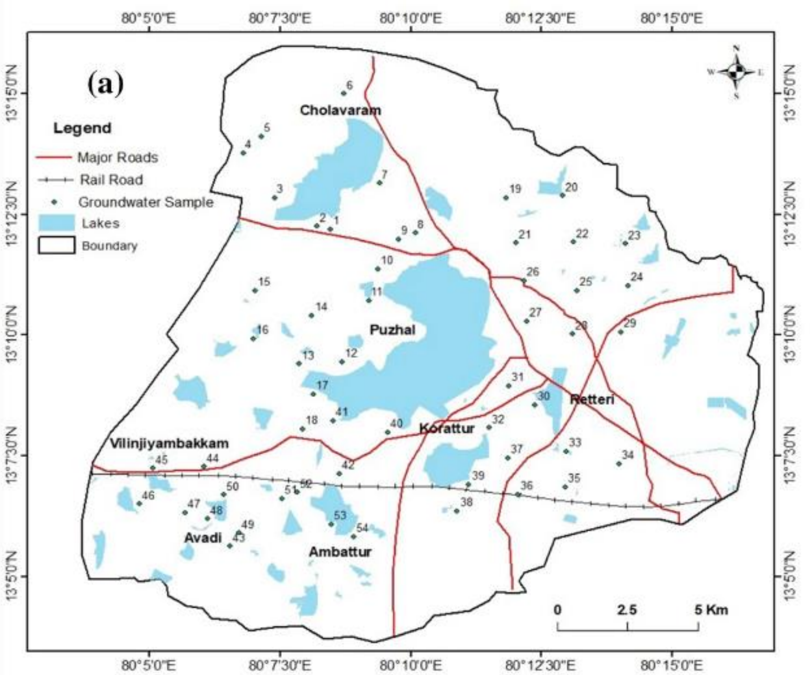


Figure 1: Sampling location of groundwater in Tamil Nadu
(Sources: Ahmed *et al.* 2020)

Preparation of the base map was essential for the survey of India topographic sheets. According to Islamic *et al.* (2017), ***Recon GPS*** has been used to determine the sample site location. Identification of the geochemical results has been plotted to determine the consequence of excessive chloride in water. Moreover, the geochemical results have been plotted in the paper liners pot for identification of the risk factors of the significant geographic area. In this method, the WQI calculation has been evaluated to identify the risk factors of this project. Computing the concentration of parameters from the sample area is essential to detect the risk factors of harsh water.

Findings and analysis

As shown in the figure 1, 7 (***Avadi, Ambattur, Puzhal, Retteri, Korattur, Cholavaren)*** locations have been selected for analysing the quality of ground water. In addition, these regions are lies among 80^{0} $_{1}$6 N latitude and the total aerial extent of the sample is approximately 358.08 km^{2}. On the other hand, the researcher has utilized the digital elevation model to detect the quality of ground water within those regions. However, the result of the sample has been indicated that the Geo Hydraulic tools of the ArcGIS is around 10.3 parameter that shows the ground water of those region are affected due to chemicals. In addition to that, it has been determined that the study area of this study has been experienced a warm climate change during summer and winter has also impose a moderate impact on the quality of ground water. As per the analysis, it has been measured that the temperature within these places varies from 18 to 27 degree Celsius. The mean temperature rarely falls below 20 degree of Celsius whereas the maximum temperature has risen up to 44 degree celli's. Apart from that, the humidity across these is also varies from 85% to 60% during the climate changes. In addition to that, the researcher has utilized an enhanced technology known as water quality index for assessing the quality of ground water. The impact of trace metals and heavy metals has not been taken under consideration in study to measure the quality of water through the inception of water quality index technology. Moreover, the HPI of this study has been calculated to measure the suitability of the groundwater of the areas that has been taken under consideration within this study. The measurement of the HPI analysis has been stated below:

$$\mathrm{HPI} = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{I=1}^{n} W_i}$$

Figure 2: Evaluation of HPI analysis
(Source: Ahmed *et al.* 2020)

In the above figure the W_i stands for the unit of weight age of a heavy metals within the substance of ground water. On the other hand, Q_i has represented the sub index of the heavy metal and the n is the unit of heavy metals that has been detected through performing the HPI analysis. However, the result of the research has indicated that the inception of trace metals and pH of the ground water within the north Chennai region has faced a massive impact on its quality due to high percentage of trace metals. Moreover, it has been determined that the inclusion of chemicals has also imposed a massive impact towards the quality of ground water. In addition, the PH water has been also found within the northern side of the TamilNadu which has affected the quality of ground water. The inception of industrial pollution and dumping of scraps is also an important aspect that has imposed a negative format of impact towards the quality of ground water in the northern region of Tamilnadu.

Identification of the statistical parameters like maximum, minimum and mean concentration value of physicochemical properties is essential for the determination of the physicochemical properties of water. The hydrological Pisces is essential to detect the concentration value of excessive material in water. The classification of WQI is essential for the identification of the risk factors of groundwater. According to Ahmed *et al.* (2020), the use of Gibb's diagram is significant to determine the physicochemical properties of water from the selected area in Tamil Nadu. Evaluation of Gibb's diagram is essential for the establishment of the chemical relationship of aquifer lithological characteristics and water composition. ***Gibb's diagram*** is used to differentiate the fields, such as evaporation dominance, precipitation dominance and interaction of dominance material in harsh water from the collected sample.

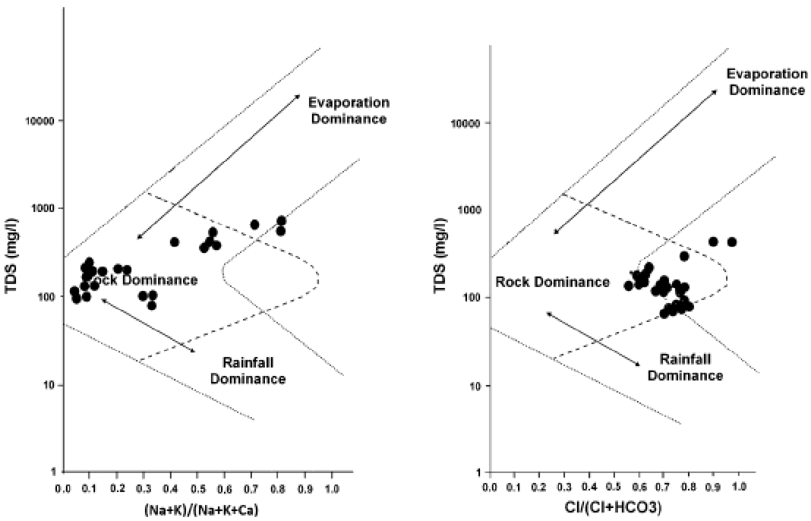


Figure 3: Gibb’s diagram
(Source: Ahmed *et al.* 2020)

The WQI is one of the innovative methods to discriminate between irritating water and drinking water. The classification of water value will be discussed in the following section.

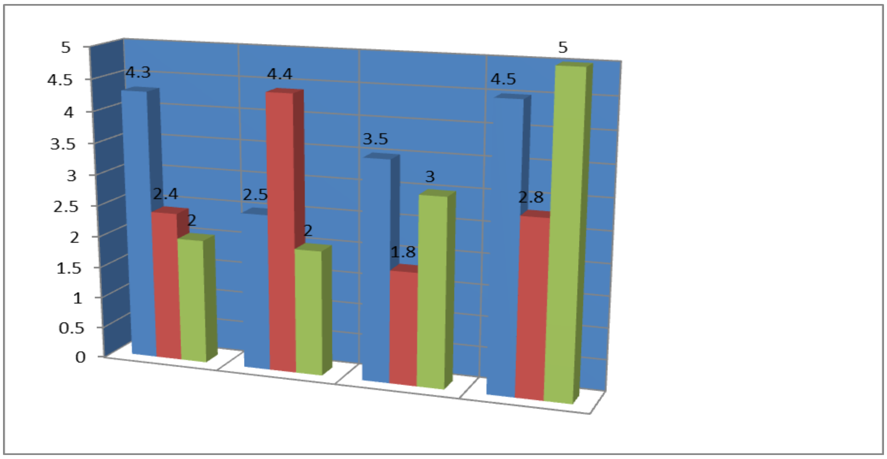
Table 2: The classification of WQI

S. No.	WQI value	Classification of water quality
1	53.69	Good

2	48.68	Excellent
3	81.71	Good
4	80.47	Good
5	110.77	Poor
6	55.95	Good
7	399.18	Unsuitable
8	92.18	Good
9	50.54	Good
10	78.61	Good
11	84.25	Good
12	110.17	Poor
13	48.63	Excellent
14	226.75	Extremely poor

(Source: Balamurugan *et al.* 2020)

The above-mentioned table has provided the value of contaminated materials in ground water. There are fourteen samples of groundwater to test the value of chloride. There are some good sources of water, which have been characterised as excellent water. Groundwater grouping is essential to ensure the quality of grounded water in Tamil Nadu.



Graph 1: Classification of WQI
(Source: MS Excel)

The above-mentioned table has provided the classification of grounded water, according to the WTI index. Water quality has been classified in good, poor, excellent and extremely poor sections. There are fourteen samples of groundwater to detect the quality of water. 226.75, WQI value detect the water quality is extremely poor. On the other hand, 399.18 WQI value determines that the quality of groundwater is unsuitable to drink. Proper classification of groundwater is essential for the identification of the risk factors of heavy metals, such as chloride (Balamurugan *et al.* 2020).

Result and Discussion

Implementation of Gibb's diagram is essential to detect the water quality, it is essential to detect the evaporation rate of water in Tamil Nadu's groundwater. Apart from Gibb's diagram, evaluation of WQI is essential to identify the hydrochemical properties in groundwater. Due to rapid urbanisation and industrialization, the groundwater has been contaminated with different hydrochemical properties (Zolekar *et al.* 2021). The analysis of hydrochemical properties is essential to erect the risk factors of harsh material in water. According to the research process, it has been detected that Cl is one of the dominant ions, which is accountable for increasing risk factors. WQI is one of the effective processes for determining anthropogenic activities in the water. Excessive chloride has detected as dominant ion in ground water. The entire process is essential to detect the physicochemical properties in groundwater.

Conclusion and recommendation

Evaluation of the WQI analytic process is essential to detect the harsh material in the grounded water. Detection of hydrochemical properties is essential for the identification of the risk factors of water. Implementation of the water quality management process will give the opportunity to reduce the risk factors of water. Reduction of risk factors will be effective to make water suitable for drinking (Maiti *et al.* 2017). Moreover, evaluation of the hydrochemical analytic process and WQI analysis will help to reduce the number of industrial wastes. Focusing on three factors will be beneficial for reducing the risk factors of grounded water. Another innovative way is to introduce an artificial recharge method and rainwater harvesting process for the fulfilment of the demand for soft water in Tamil Nadu.

WQ analysis or hydrochemical analysis is essential to reduce the risk factors of harsh or heavy materials in the groundwater. Increasing urbanisation, industrialisation and increasing population are accountable for increasing the demand for water resources. Implementation of the hydrogeochemical analysis process is essential for reducing the risk factors of water at Tamil Nadu in India. Governmental and non-government authorities need to include for reducing the risk factors of grounded water.

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