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Spatial Variation in Spring's Water Quality in Chandel District, Manipur

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Abstract:** Physio-chemical parameters namely temperature, pH, electrical conductivity, total suspended solids, chloride content and rate of discharge of spring's water from 92 (ninety-two) sampling locations in Chandel district were studied. Measurement of rate of discharge, temperature, electrical conductivity and pH were carried on the site of sampling, whereas other parameters were analysed in laboratory. The measurement and analysis results showed that the discharge of spring's water at the sampling locations range from 0.014x 10^{-5} – 3.7 x 10^{-5} m^3/s, temperature from 18 – 31˚C, pH from 6.5 – 9.2, electrical conductivity from 10 – 640 µS, Total suspended solids from 1 – 180 mgL^{-1} and chloride content range from 4 – 64 mgL^{-1}. The average values were 0.212 x 10^{-5} m^3/s, 23.97˚C, 7.92, 131.65 µS, 13.66 mgL^{-1} and 19.52 mgL^{-1} respectively. By comparing the quality of spring water with the standards, the values of the parameters did not exceed and are within the permissible limit prescribed by World Health Organization (WHO). Further, multivariate analysis (using cluster analysis) was carried out to identify the spatial relationship of the spring's water quality between the sampling locations. The results showed that out of total sampling station, 69 (sixty-nine) has similarity of about 60-70 %, whereas 5(five) sampling locations has about 90% similarity and remaining 18 (eighteen) has only about 45% similarity. Amongst the spring's water quality, the samples collected from Chakpikarong sub-division have higher water quality.
***Keywords:** Spring's water quality; Spatial variation; Multivariate analysis; Cluster analysis.*

I. INTRODUCTION

The quality of water is often assessed by examining the physical, chemical and biological characteristics of the water. It further helps in assessing the feasibility of the water for human, irrigation and industrial usage. The most important task is constant monitoring of the water parameters to determine the degree of pollution of water source to protect the natural environment and public health. The spring water quality consistency depends on various factors such as climatic condition, types and characteristics of subsoil.

Therefore, it is essential to have a control system which highlights the changes in water characteristics; thereby mitigation measures can be taken up in time to restore the original quality of water [1]. The groundwater qualities are highly susceptible to pollution and anthropogenic contaminants.

In fact, variety of processes, such as inputs from surrounding environment, interactions of soil and rock, and chemical inputs from anthropogenic activities and natural effects usually impair the ground water and its uses [2]. Also, degradation of the ecosystem in turn decreases the number of spring's water source or may decline the rate of discharge including the shifts in chemistry and consistency of spring water [3].

Some of the widely used multivariate analysis tools such as Principal component analysis (PCA), Factor analysis (FA), and Cluster analysis (CA) were utilized to develop the control systems which evaluate large and complex multi-variables data. While evaluating and analysing the data, such tools also create new variables by reducing the number of original variables [4]. PCA, PA and CA have the potential to group the sets of variables according to their characteristics which further simplify the data sets by identifying the structures or patterns in the data. Such tools also help in elaborating the similarity from various non-homogeneous variables, while considering the chemical, physical and microbiological parameters at the same time. Such capacity of the tools enables us to identify the potential association and correlation between the parameters for analytical solutions [1].

In this study, multivariate statistical techniques have been used to classify the spring's water consistency and to verify the spatial variations caused by natural and anthropogenic factors. The cluster analysis technique is adopted for this study which will allow us to indicate the similarities or differences within the sampling locations.

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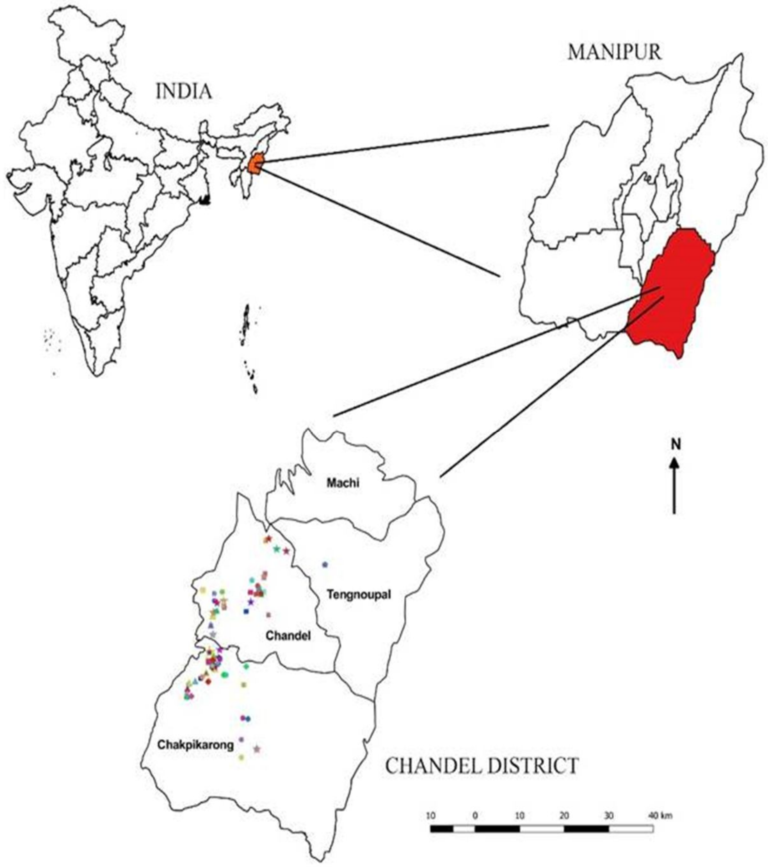

Fig. 1: Map of the study area (Dotted colors indicates spring's water sampling locations)

II. MATERIALS AND METHODS

A. Study Area

The area of study is constrained to the Chandel District which lies in the south-eastern part of Manipur (India) as shown in Fig. 1. It is the state's boundary district. The neighbors are Myanmar to the south, Ukhrul district (Manipur) to the east, Churachandpur district (Manipur) to the south-east and Thoubal district (Manipur) to the north. It is around 64 km from Imphal, capital of Manipur. Its area spreads to 3313 square km. The NH39 passes through Chandel district. The district had sub-tropical to temperate weather conditions with temperatures varying between 5˚C to 35˚C. The monsoon period occurs between May and August having an average of 1036 mm of annual rainfall [5].

The district has parallel hill ranges mainly along north-south, consisting of consolidated and semi-consolidated rocks. These rocks are restricted in the eastern part towards the border with Myanmar, while the semi-consolidated formations cover nearly the entire foot valley area towards the Imphal valley comprising shale, siltstone, sandstone and conglomerate. These formations belong to the rock groups Disang, Barail, Surma and Tipam. Unconsolidated alluvium from Quaternary Age occurs in the central part of the valley [5]. Spring water is one of the district's primary sources of water supply.

B. Sampling and Methods of Analysis

The study was carried out using the data gathered from the well-known sources of spring water in around Chandel district. Our study has been performed in 2019 between September-November. A total of spring's water samples from 92 sources were collected, spreading across the district. From which 54 sources were collected from Chakpikarong sub-division and the remaining 38 from the Chandel sub-division. Data analysis were carried out which was used to create the evaluation set. Samples collected were kept at room temperature before the analysis. For every sample, 5 physio-chemical parameters were analyzed. The analyses were conducted within 48 hours of the sampling date using the APHA Standard procedures [6]. The physio-chemical parameters were discharge, electrical conductivity, pH, temperature, total suspended solids and chloride content.

C. Statistical Software

The implementation of the statistical multivariate algorithms is assisted by the following software package: "Minitab Release 16®". The Minitab software enables Cluster Analysis to be conducted on a data matrix in which each object is represented from a set of variables. The technique uses an algorithm that transforms the original data matrix in a distance matrix and then in a similarity matrix.

D. Multivariate Analysis

1) *Cluster Analysis:* In general, the useful information is collected based on data gather from the sampling locations. This goal can be achieved to identify the groups of objects built on the variables [7]. Methods of cluster analysis provide the means to classify the given data into groups (clusters), based on measures of similarity or closeness. Using the principle of distance, it can be quantified mathematically. The basic distances used are classified as Euclidean, Manatthan, Chebyshev, Camberra and Pearson [8]. The final clustering depends on combination of clustering approach used and the calculation of distance taken. Nowadays, agglomerative hierarchical approaches are the most cited in literature [9]. The groups are created in this approach by combining the objects into bigger and larger clusters. The product of the process is shown by a graphic called dendogram which allows a good vision of the similarity between the objects being studied. The hierarchical agglomerative cluster algorithm used in this work was the Ward's method, whereas the distance elaboration was achieved by following the Euclidean distance.

III. RESULTS AND DISCUSSION

The discharge of the springs' water ranges from $0.014x\ 10^{-5} – 3.7\ x\ 10^{-5}\ m^3/s$, with an average value of $0.212\ x\ 10^{-5}\ m^3/s$. This suggest that each spring's water may be able to supply water to a few people only, which means it is ideal for a small community or village. Electrical conductivity of the spring's water ranges from 10 – 640 µS with an average value of 131.65 µS. This indicates that the amount of dissolved ionic components presents in the spring's water were medium to high in most of the samples. However, the samples with least electrical conductivity of 10 µS were from three sampling locations, namely, Everkhong of Japhou village (Chandel sub-division) and Dulin springs of Khubung Khunou village (Chakpikarong sub-division). The highest electrical conductivity of 640 µS was from the Kopil Dukong spring of Salluk village (Chakpikarong sub-division). Whereas, pH values range from 6.5 – 9.2 with an average value of 7.92 but samples having least pH values was from U.P Dukong of Chakpikarong village, Everkhong of Japhou village and Dulin springs of Khubung Khunou village. Spring's water of Salluk Lok of Akaphe village (Chakpikarong sub-division) and Shilnam Lok of Lamkang Khunou village (Chandel sub-division) has the highest pH value. For drinking purposes, World Health Organization has recommended a pH value of 6.5 or more to avoid corrosion [10] while pH value of 8.0 adversely affects the analysis and disinfection of chlorinated drinking water [11]. On the other hand, pH values within 6.5 and 8.5 generally marks an acceptable water quality. Temperature values for groundwater in the study area ranges from 18 – 31˚C with an average value of 23.97˚C. These proposed that the temperatures at spring's water in the district are typically favorable for use by the people who need cool to lukewarm water. Water with high temperatures gives adverse effect which results in increasing the problem of corrosion, color, odor and taste, caused by the micro-organisms present in it [11]. It is therefore critical, as the temperature of the spring's water is not too high to prevent microbial proliferation.

Total suspended solid (TSS) values ranges from 1 – 180 mgL^{-1}, the highest recorded was from Apudu spring of Khubung Khunou village (Chakpikarong sub-division) while Nungshi Lok of M.Tolpijang village (Chakpikarong sub-division) and Alhru spring of Maha Mani village (Chandel sub-division) recorded the least TSS value. The TSS value for the study area has an average of 13.66 mgL^{-1}. TSS is the water quality measure with the most visibility. It is considered that clear water is usually considered healthy water. TSS is important in terms of water aesthetics since, the more suspended solids present the less clear the water will become. Excessive suspended solids can cause concern for human and aquatic life. The chloride content in the study area ranged from 4 – 64 mgL^{-1} with an average value of 19.52 mgL^{-1} which is relatively low. The least value was recorded from Apudu spring of Khubung Khunou (Chakpikarong sub-division) and the highest value were from Kholpisoo spring of P-Khudam village (Chakpikarong sub-division). The concentrations of chloride exceeding 250 mgL^{-1} can cause detectable taste in water but the chloride anion taste thresholds are dependent on the related cations. No guideline value for chloride in drinking water based on health is proposed [10].

From the multivariate analysis (using cluster analysis), six clusters were used to identify the similarity of 92 sampling stations. Cluster 1 having 18 stations (8 from Chandel sub-division and 10 from Chakpikarong sub-division) has about 45% similarity, Cluster 2 with 29 stations (18 from Chandel sub-division and 11 from Chakpikarong sub-division) has about 71%, Cluster 3 having 17 stations (3 from Chandel sub-division and 14 from Chakpikarong sub-division) has about 71%, Cluster 4 having 5 stations (1 from Chandel sub-division and 4 from Chakpikarong sub-division) has about 90%, Cluster 5 with 8 stations (all 8 from

Chakpikarong sub-division) has about 75% and Cluster 6 with 15 stations (8 from Chandel sub-division and 7 from Chakpikarong sub-division) has about 60%. Out of which, Cluster 1 which consists most of the sampling locations in Chakpikarong sub-division, has the least value of electrical conductivity, pH and temperature ranging from 10 – 84 µS, 6.6 – 8.4 and 18 – 26.67˚C with an average of 56.89 µS, 7.56 and 22.57˚C respectively. Cluster 2 comprising of mainly Chandel sub-division has the least value of TSS ranging from 1 – 29mg L^{-1} with an average of 7.83mgL^{-1} and Cluster 5 having all the sampling locations in Chakpikarong sub-division has the least value of chloride ranging from 10 – 20mgL^{-1} with an average of 15.25mgL^{-1}.

IV. CONCLUSION

The measured physio-chemical parameters values from the sampling locations suggest that the spring's water quality is fit for human usage. The application of the established method by cluster helps the list of spring's in Chandel district in identifying the group of sampling locations having similar water quality. Also, the method enables to supervise significant variation in the water quality characteristics and identify the chemical parameters affecting the water quality. Most of the sampling locations in Chakpikarong sub-division, has the least value of electrical conductivity, pH and temperature out of the five parameters as compare to the others. So, the spring samples present in Chakpikarong sub-division is the best among other samples. Although, others important chemical parameters, not included in the study, are needed to draw overall conclusion on water quality, but the spring's water in and around the study site can be conserved in a central location and supplied to the population for efficient utilization.

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