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# Seasonal Distribution of Trace Metals in Groundwater of Dhemaji District, Assam, India

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**Abstract:** A comprehensive study has been carried out with respect to chromium, manganese, zinc, copper and nickel contamination of groundwater in Dhemaji district of Assam, India. Twenty groundwater samples were collected from tube well and ring well in both dry and wet seasons. The metals were analysed by using Atomic Absorption Spectrometer, Perkin Elmer AA 200 model. Normal distribution and correlation analysis have been employed to find out the distribution pattern of the metals in the area. It is ascertained that a sizeable number of groundwater samples contain chromium, manganese and nickel at toxic level. Copper and zinc content of groundwater was found to be within the guideline value of WHO. High concentrations of all the trace metals except for chromium were recorded in the dry season than in the wet season. Statistical analyses of the data reveal that the distribution of various metals in the study area is widely off normal. The metal concentration of groundwater in the district follows the trend Zn>Mn>Cr>Cu>Ni in both the seasons.

**Keywords:** Chromium, Manganese, Zinc, Copper, Nickel, Groundwater.

## Introduction

Groundwater has been used as a source of drinking water for millions of rural and urban families in India. As it is very limited and vulnerable resource, every effort should be made to achieve groundwater quality as safe as practicable. But unfortunately due to lack of proper groundwater quality-monitoring network and appropriate water resources management has resulted in groundwater contamination in many parts of India. The problem of groundwater pollution due to trace metals has now raised concerns all over the globe and results reported by various researchers have been alarming [1-4]. There is also evidence of prevailing trace metal contamination of groundwater in many areas of India [5-9]. The elevated level of trace metals in groundwater is a new public concern in Dhemaji district of Assam. Knowledge of the concentration and distribution pattern of trace metals in groundwater can play an important role in estimating the sources of groundwater pollution, especially in rural districts like Dhemaji where a large section of rapidly growing people of low economic background exists. The primary objective of this study is to present a statistically meaningful water quality database on trace metal contamination of groundwater and their seasonal distributions if any with special reference to chromium, manganese, zinc, copper and nickel in Dhemaji district so that purpose-orientated water assessments and predictions can be made in the area.

## Study area

The study area Dhemaji district is situated in the eastern parts of India on the northeast corner of Assam. Located between mighty river Brahmaputra and Himalayan foothills of Arunachal Pradesh, the district is largely plain with some hills. The district is located between $27^0$ $05^/$ $27^{//}$ and $27^0$ $57^/$ $16^{//}$ northern latitudes and $94^0$ $12^/18^{//}$ and

$95^0$ $41^/$ $32^{//}$ eastern longitudes. The district is divided into two sub-divisions viz. Dhemaji and Jonai, comprising of five development blocks viz. Dhemaji, Sissiborgaon, Bordoloni, Machkhowa and Morkongselek (Tribal).

## Materials and Methodology

For the present study, twenty groundwater samples were collected from tubewells and ringwells at different sites from each of the five development blocks of Dhemaji district during dry and wet seasons to assess the qualitative changes in metal loads. Samples were collected once in a week in both dry and wet seasons by random selection and combined together in clean and sterile one-litre polythene cans to obtain a composite sample and stored in an ice box [10]. The sampling locations are shown in **Figure 1.** All possible safety measures were taken at every stage, starting from sample collection, storage, transportation and final analysis of the samples to avoid or minimize contamination. Chromium, manganese, zinc, copper and nickel were analysed by using Atomic Absorption Spectrometer (Perkin Elmer AA 200) as per the standard procedures[11].

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. The observed parameters are related graphically. Sample data are also subjected to statistical treatment using normal or Gaussian distribution statistic and correlation analysis. Some more statistical estimates derived from the normal distribution in the forms of kurtosis, skewness and quartile are also calculated to find out the distribution pattern, localisation of data, and other related information.

## Results and Discussion

The experimental results are presented in **Table 1**. To look into the seasonal variations and distribution patterns of the metal contents in groundwater, data were exposed to several statistical treatments. Descriptive statistics based on normal distribution has been summarised for both dry and wet season in **Table 2** and **Table 3** respectively. Correlation analyses were performed by Pearson's product moment correlation and are presented in **Table 4** and **Table 5**. Seasonal distributions of various metals in groundwater are graphically presented in **Figure 2-6**.

In the present study chromium content in groundwater are found to be above the permissible limit of WHO with a mean value of 0.1025 ppm and 0.1330 ppm respectively in dry and wet season. It may be seen from Table 1 that some of the water samples contain chromium at toxic levels. The skewness and kurtosis values for chromium in both the seasons indicate that its distribution in the study area is not uniform. The distributions for chromium in groundwater appear to be asymmetric with the common feature of third quartile being wider than the second.

Manganese concentration in groundwater was found to be within the range of 0.08–1.35 ppm during dry season and 0.06–0.90 ppm during wet season. It is observed that groundwater samples of Dhemaji district fall under alert category with respect to manganese as some of the samples exceed and some are approaching the WHO guideline value of 0.4 ppm[12] (Table 1). Wide data range and high standard deviation in case of manganese in both dry and wet season are likely to bias the normal distribution statistic. Significant differences among mean, median and mode along with significant skewness and kurtosis values observed for manganese in both the seasons are indicative of departure of sample frequency distribution curve from normal. It seems that in both the season manganese distribution in the area is sharp with a long asymmetric right tail.

The concentration of zinc in groundwater is usually below 10–40 µg/litre [13]. Zinc is a nutritionally essential element. It is necessary for growth and is involved in several physiological functions. In all the samples under investigation, the zinc contents are much below the guideline value of 5 ppm. Negative kurtosis and Positive skewness values obtained for zinc in both the season indicates flat distribution pattern with a long left tail. Asymmetric nature of zinc distribution is also apparent from the width of the third quartile which is much greater than the first and second quartile in both the seasons.

In the groundwaters, copper levels are low with the majority of samples being below detection limits. Where the metal concentrations are above detection limits, they still fall below the WHO guidelines value of 2 ppm. Copper is an essential micronutrient, but in high concentration causes physiological effects in human. Water containing 3 mg copper/L was associated with gastrointestinal disturbance in adults, whereas water containing 1 mg/L was not [14]. Copper shows higher concentration during dry season. Positive kurtosis and skewness value for copper in both the season is indicative of its sharp asymmetric distribution with a long right tail from its median. It is also observed that the width of the third quartile is significantly greater than the second quartile, which for a symmetric distribution should be equal.

It has been observed that nickel content of groundwater at some of the sampling sites is very high. Average nickel contents in groundwater in both dry and wet season fall outside the maximum permissible limit of 0.02 ppm as set by WHO. The maximum value is obtained at site C1 during wet season. Nickel distribution in the area is found to be flat during dry season and sharp during wet season with asymmetric tail pointing towards right of the median.

During the study, seasonal variations are also observed for all the trace metals under investigation. Except for chromium, higher values for all the trace metals are obtained in the dry season than in the wet

season. By comparing the average values of all the trace metals, it is observed that the metal content of groundwater in the district follows the trend Zn>Mn>Cr>Cu>Ni in both the seasons. Pearson's correlation coefficient matrix, employed for measuring the linear association among chromium, manganese, zinc, copper and nickel, shows that some of the metals are significantly co-related at the 0.05 level (Table 4 and 5).

## Conclusion

Statistical observations on chromium, manganese, zinc, copper and nickel in groundwaters of Dhemaji district, Assam show that all these metals exhibit a non-uniform distribution. Comparing the water content of trace metals with the recommended maximum values for drinking purposes, it is found that a sizeable number of groundwater samples contain chromium, manganese and nickel at an alert level. The concentrations of copper and zinc in the groundwater of the area are either low or moderate and within the guideline values of WHO. Keeping in view of the unusually high concentrations of the harmful metals at some of the sampling sites, it is concluded that regular monitoring of water sources should be ensured by the concerned authorities to prevent the outbreak of water borne diseases in the area.

**Table: 1 Metal content in groundwater of Dhemaji district at 20 different stations**

| Sample No | Sampling Station | Season | Cr (in ppm) | Mn (in ppm) | Zn (in ppm) | Cu (in ppm) | Ni (in ppm) |
|---|---|---|---|---|---|---|---|
| A1 | Bishnupur | Dry | 0.02 | 0.08 | 0.15 | BDL | 0.02 |
| | | Wet | 0.02 | 0.06 | 0.11 | BDL | 0.01 |
| A2 | Lakhipathar | Dry | 0.11 | 0.23 | 1.78 | BDL | 0.02 |
| | | Wet | 0.05 | 0.21 | 1.24 | BDL | BDL |
| A3 | Aradhal | Dry | 0.10 | 0.09 | 0.27 | BDL | 0.03 |
| | | Wet | 0.03 | 0.08 | 0.35 | BDL | 0.02 |
| A4 | Moridhal | Dry | BDL | 0.43 | 0.80 | BDL | 0.06 |
| | | Wet | BDL | 0.40 | 0.70 | BDL | 0.04 |
| B1 | Sissiborgaon | Dry | BDL | 0.23 | 0.40 | 0.02 | 0.05 |
| | | Wet | 0.01 | 0.25 | 0.60 | BDL | 0.04 |
| B2 | Silliest | Dry | BDL | 0.24 | 0.02 | 0.01 | 0.04 |
| | | Wet | BDL | 0.21 | 0.07 | BDL | 0.03 |
| B3 | Striping | Dry | BDL | 0.44 | 1.10 | BDL | 0.06 |
| | | Wet | 0.01 | 0.46 | 1.03 | BDL | 0.05 |
| B4 | Malinipur | Dry | 0.31 | 1.30 | 0.40 | 0.03 | 0.03 |
| | | Wet | 0.27 | 0.91 | 0.37 | BDL | 0.03 |
| C1 | Machkhowa | Dry | 0.17 | 0.36 | 1.10 | 0.04 | 0.07 |
| | | Wet | 0.20 | 0.41 | 1.30 | 0.04 | 0.08 |
| C2 | Begenagara | Dry | 0.12 | 0.31 | 1.20 | 0.07 | 0.02 |
| | | Wet | 0.19 | 0.28 | 1.30 | 0.02 | BDL |
| C3 | Jorkata | Dry | 0.26 | 0.25 | 1.20 | 0.27 | 0.04 |
| | | Wet | 0.22 | 0.25 | 1.10 | 0.23 | 0.05 |
| C4 | Sissimukh | Dry | 0.17 | 0.22 | 1.75 | 0.25 | 0.02 |
| | | Wet | 0.23 | 0.27 | 1.17 | 0.32 | 0.02 |
| D1 | Bordoloni | Dry | 0.23 | 0.15 | 0.56 | 0.06 | 0.01 |
| | | Wet | 0.19 | 0.20 | 0.44 | 0.06 | BDL |
| D2 | Gogamukh | Dry | 0.15 | 0.17 | 0.36 | 0.02 | 0.02 |
| | | Wet | 0.25 | 0.20 | 0.25 | BDL | 0.05 |
| D3 | Borbam | Dry | 0.12 | 0.11 | 0.45 | 0.42 | 0.03 |
| | | Wet | 0.19 | 0.09 | 0.30 | 0.36 | 0.04 |
| D4 | Mingmang | Dry | 0.24 | 0.14 | 0.36 | 0.03 | 0.02 |
| | | Wet | 0.31 | 0.13 | 0.23 | 0.02 | 0.01 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| E1 | Simen Chapari | Dry | BDL | 0.25 | 0.30 | 0.05 | 0.05 |
| | | Wet | 0.02 | 0.20 | 0.50 | 0.30 | 0.04 |
| E2 | Laimekuri | Dry | BDL | 0.22 | 0.05 | 0.05 | 0.03 |
| | | Wet | 0.02 | 0.20 | 0.08 | BDL | 0.05 |
| E3 | Telem | Dry | BDL | 0.42 | 1.05 | 0.20 | 0.05 |
| | | Wet | 0.20 | 0.45 | 1.03 | BDL | 0.04 |
| E4 | Jonai | Dry | 0.05 | 1.35 | 0.45 | 0.02 | 0.02 |
| | | Wet | 0.25 | 0.90 | 0.36 | BDL | 0.03 |

*BDL: Below Detection Limit

**Table: 2 Comparison of statistical data of different metals in dry season**

| Statistics | Cr | Mn | Zn | Cu | Ni |
|---|---|---|---|---|---|
| Mean | 0.103 | 0.350 | 0.688 | 0.077 | 0.035 |
| Standard Error | 0.023 | 0.078 | 0.118 | 0.026 | 0.004 |
| Median | 0.105 | 0.235 | 0.450 | 0.030 | 0.030 |
| Mode | 0.000 | 0.220 | 0.360 | 0.000 | 0.020 |
| Standard Deviation | 0.102 | 0.350 | 0.528 | 0.115 | 0.017 |
| Variance | 0.010 | 0.123 | 0.279 | 0.013 | 0.000 |
| Skewness | 0.549 | 2.415 | 0.782 | 1.965 | 0.630 |
| Kurtosis | -0.907 | 5.260 | -0.339 | 3.307 | -0.700 |
| Range | 0.310 | 1.270 | 1.760 | 0.420 | 0.060 |
| 1st Quartile | 0.000 | 0.155 | 0.315 | 0.003 | 0.020 |
| 2nd Quartile | 0.105 | 0.235 | 0.450 | 0.030 | 0.030 |
| 3rd Quartile | 0.170 | 0.405 | 1.100 | 0.068 | 0.050 |

**Table: 3 Comparison of statistical data of different metals in wet season**

| Statistics | Cr | Mn | Zn | Cu | Ni |
|---|---|---|---|---|---|
| Mean | 0.133 | 0.308 | 0.627 | 0.068 | 0.032 |
| Standard Error | 0.025 | 0.052 | 0.098 | 0.028 | 0.005 |
| Median | 0.190 | 0.230 | 0.470 | 0.000 | 0.035 |
| Mode | 0.020 | 0.200 | 1.030 | 0.000 | 0.040 |
| Standard Deviation | 0.111 | 0.234 | 0.440 | 0.124 | 0.021 |
| Variance | 0.012 | 0.055 | 0.194 | 0.015 | 0.000 |
| Skewness | -0.016 | 1.744 | 0.378 | 1.678 | 0.167 |
| Kurtosis | -1.800 | 2.830 | -1.470 | 1.200 | 0.070 |
| Range | 0.310 | 0.850 | 1.230 | 0.360 | 0.080 |
| 1st Quartile | 0.020 | 0.200 | 0.263 | 0.000 | 0.013 |
| 2nd Quartile | 0.190 | 0.230 | 0.470 | 0.000 | 0.035 |
| 3rd Quartile | 0.228 | 0.408 | 1.083 | 0.055 | 0.048 |

**Table: 4** Pearson's correlation matrix of groundwater samples during dry season

| Correlation | Cr | Mn | Zn | Cu | Ni |
|---|---|---|---|---|---|
| Cr | 1.000 | 0.143 | 0.221 | 0.245 | -0.395 |
| Mn | 0.143 | 1.000 | -0.023 | -0.178 | 0.035 |
| Zn | 0.221 | -0.023 | 1.000 | 0.284 | 0.086 |
| Cu | 0.245 | -0.178 | 0.284 | 1.000 | -0.060 |
| Ni | -0.395 | 0.035 | 0.086 | -0.060 | 1.000 |

**Table 5** Pearson's correlation matrix of groundwater samples during wet season

| Correlation | Cr | Mn | Zn | Cu | Ni |
|---|---|---|---|---|---|
| Cr | 1.000 | 0.340 | 0.134 | 0.186 | -0.043 |
| Mn | 0.340 | 1.000 | 0.142 | -0.260 | 0.209 |
| Zn | 0.134 | 0.142 | 1.000 | 0.144 | 0.088 |
| Cu | 0.186 | -0.260 | 0.144 | 1.000 | 0.106 |
| Ni | -0.043 | 0.209 | 0.088 | 0.106 | 1.000 |

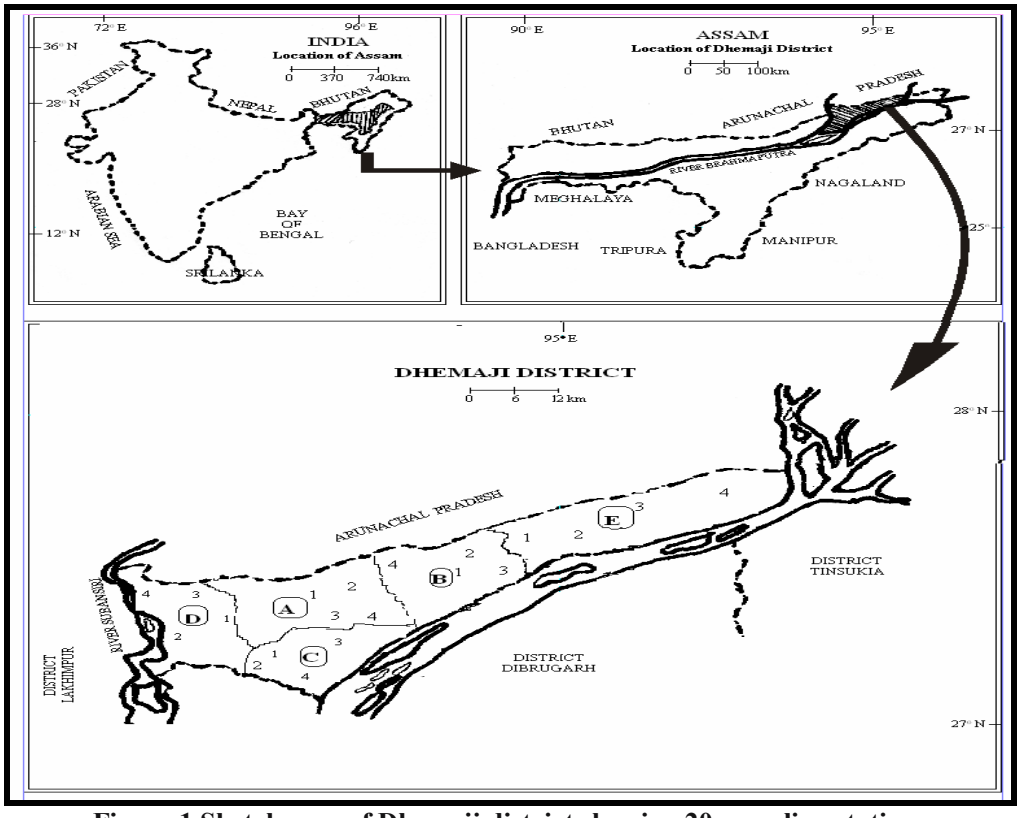


**Figure 1 Sketch map of Dhemaji district showing 20 sampling stations**

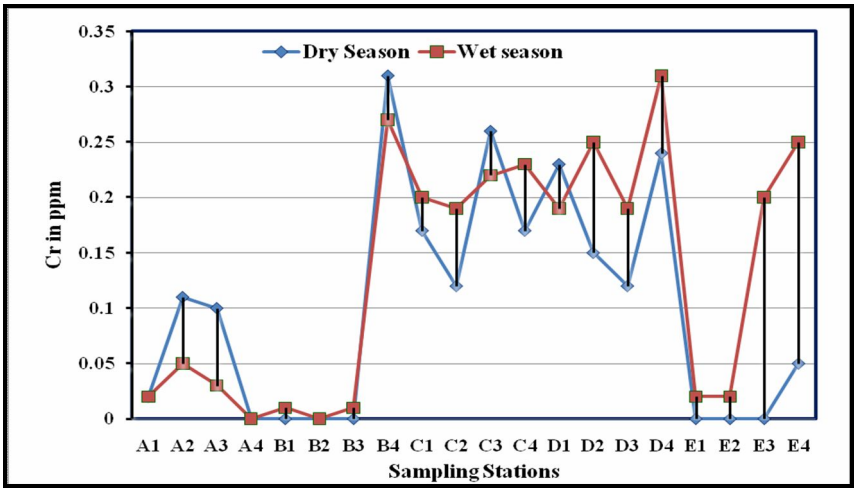


**Figure 2 Seasonal variations of Cr in the study area.**

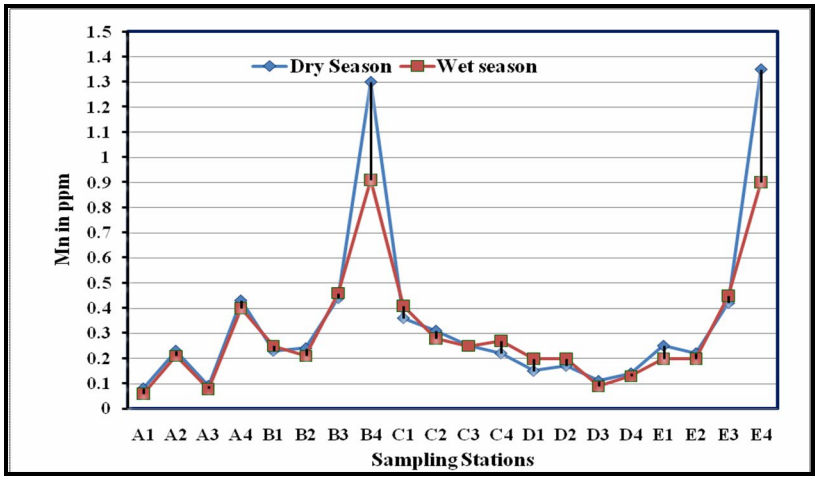


**Figure 3 Seasonal variations of Mn in the study area.**

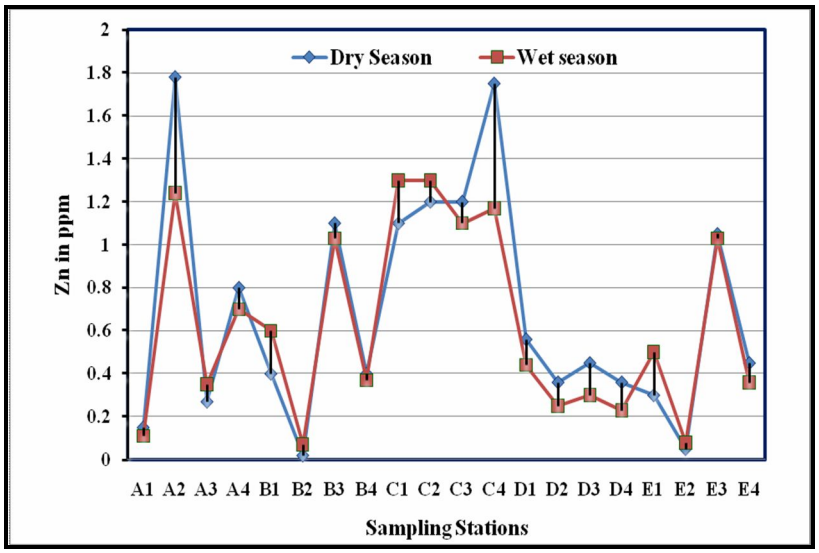


**Figure 4 Seasonal variations of Zn in the study area.**

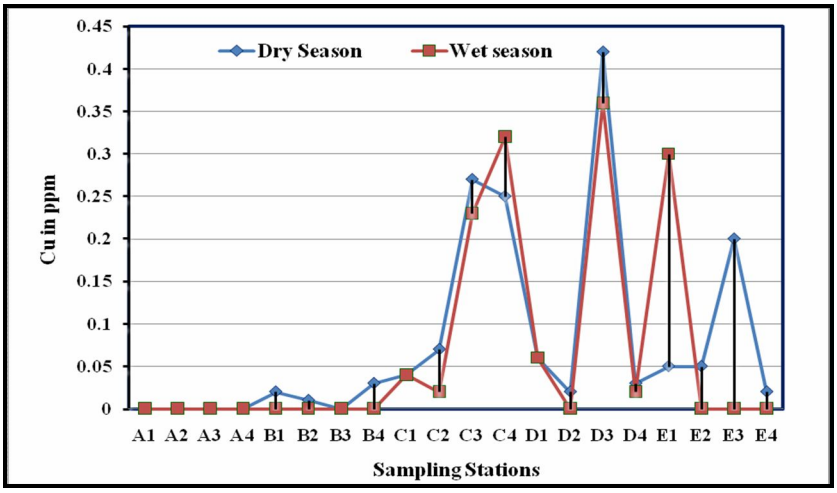


**Figure 5 Seasonal variations of Cu in the study area.**

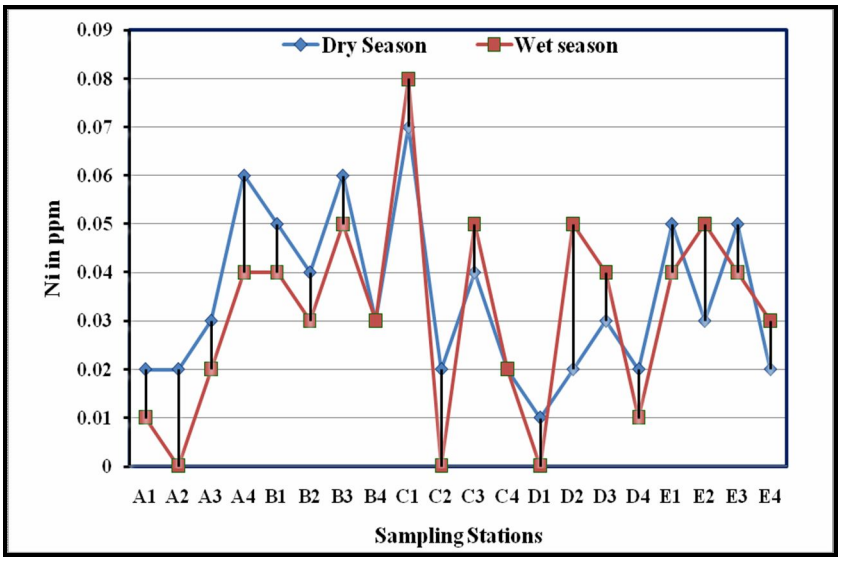


**Figure 6 Seasonal variations of Ni in the study area.**

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