On Water Quality of Nagaland, North-eastern India: A Short Review and Statistical Analyses

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Abstract: Water is an integral part for human survival but around 2.1 billion people do not have excess to safe drinking water and 4.5 billion people lack proper sanitation. The human needs and demands have built up the rapid growth of industrialization which alternatively has severely affected the stability of water. In the case of Nagaland, there is a mass knowledge gap on water related problems and its ill effects among locals which have not been identified to this extent. Dimapur district of Nagaland being the fastest developing city of Nagaland has severely affected major sources of water bodies but monitoring and documentation on the water bodies is very scanty. In this article we have presented some articles from neighboring northeastern states of India as Nagaland shares its boundary to these states and have similar geographical features. Then secondary data from research articles of Nagaland was examined to understand the contamination level in the region. Further statistical methods such as descriptive statistics, Correlation, regression, factor analysis was analyzed on the secondary data to give a better understanding on the behavior of water pollutants within the region.

Keywords: *Water quality, Nagaland, Pollutants, Correlation, Regression.*

Introduction

Water is essential for life and terrestrial life including humans need fresh water for survival. According to WHO and UNICEF about 2.1 billion of people do not have excess to an improved drinking water source and the number of children death under five due to diarrhea amounted to 526000 in 2015. However, Water pollution in India is a major problem. Due to industrialization and urbanization, the problem seems to have risen higher and more gigantic. Nagaland is located in the Northeastern part of India is ethnic with diverse tradition and cultural heritage. Rivers forms an integral part of geography in Nagaland. In Nagaland the predominant source of drinking water is from surface water such as river, streams, natural springs and ground water. The hilly part of the region is entirely dependent on surface water whereas the plain area as such Dimapur is dependent on ground water and surface water as well. Ground water is a major source for drinking water and also used in agriculture and industry. The local people of Dimapur district are predominantly dependent on ground water and surface water too. Dimapur district being the fastest urbanization and industrialization of Nagaland state could lead to depletion of ground water where rapid usage of chemical fertilizers, pesticides and dumping of sewage are seen day to day. However, recent reports on water quality of Dimapur are very limited to best of our knowledge. One major issue in Nagaland especially Dimapur district is the untreated municipal waste dumped nearby rivers which causes not only ground and surface water deterioration but also has an adverse effect on human health. No proper sanitation has been done so far in order to curb the prevailing the dumping of waste. Therefore, systematic monitoring on ground water bodies is required on a varied scale with quantitative assessment of different physicochemical parameters, metal contamination and micro-biological characteristics. In this paper we have presented research articles related to water pollution in the adjoining the areas of Nagaland viz. Assam and Manipur due to its similar geography and geochemistry including available articles related to water pollution of Nagaland. Statistics in an integral part used in many research fields not only in business, government offices and hospital due to its large application of large data reduction or helps in drawing a conclusion. Statistical methods have been implied in the articles using the secondary data in order to draw the pattern of water contamination of Nagaland.

Literature review

The quality of ground and Surface water within a region is governed both by natural and anthropogenic effects. It is also important to note the quality of groundwater is primarily used for agricultural, domestic and Industrial purposes[1]. India is currently the world's largest consumer of groundwater and many researchers have focused on the contamination of groundwater as well as surface water mainly due to its anthropogenic sources [2]. Coal extractions as in the case in India has contributed to wealth and employment but simultaneously exerted a long lasting impact on the ecosystem leading to the degradation of soil and water bodies [3–5]. The contamination in the water bodies is evident by low pH, high sulphate, TDS, EC, Fe, Cd, Hg, Pb and As concentration studied in Assam and Nagaland [6–8]. However, the increasing anthropogenic influences in recent years in urban, suburban, rural and catchment areas have potentially led to deterioration in the water quality. The physico-chemical characteristics are substantially affected due to discharge of municipal waste, domestic and industrial, recreational, religious offering etc. Recent Research studies carried in the various parts of Manipur depicts that majority of the water sample consists of high TDS, turbidity, total hardness, BOD, Na^+, Cl^-, phosphate, EC which is mainly caused due to untreated domestic waste, disposal of solid waste making it unfit for drinking (Alam and Gyanendra, 2017; Raj Kumar Bronson Singh et al., 2016; Singh and Dey, 2014; Singh et al., 2017). But the most common health risk associated with drinking water is microbial contamination since it has the potential to cause large outbreak of water borne diseases. Contamination in drinking water in India either by domestic, animal and human excreta is a common factor. Untreated disposing of human excreta in many parts of Northeast India especially Nagaland is one of the common problems which can lead to variety of water borne diseases such as gastroenteritis, dysentery, skin infection, cholera, typhoid etc. Most of the water bodies under investigation were contaminated with water-borne pathogenic bacteria either from anthropogenic sources or socio-cultural activities as reported in Golaghat, Karbi-Anglong, Dibrugarh, and Barak river of Assam [14–17].

Arsenic is a naturally occurring metalloid element which is present in air, food and water. However, prolong exposure to arsenic cause's diseases i.e. skin and lung cancer, keratosis, melanosis, pigmentation etc. Drinking water is one of the pathways of exposure to arsenic and is a major problem of global concern [18–20]. Studies relating to arsenic contamination were observed in six tea gardens of Lakhimpur district of Assam, India where a good number of water sample contains arsenic at an alert and toxic level [21]. Similar studies by different researcher on arsenic pollution were also done on the different parts of Assam viz. Jorhat [22,23], Brahmaputra and Barack flood plains[24], Golaghat [25], Lakhimpur [26], Sonitpur, Nagaon, Kamrup, Nalbari and Darrang [27] depict the alarming high concentration of Arsenic which have been caused due to geogenic origin. A recent report by UNICEF registered 18 out of the 23 districts were affected by ground water arsenic toxicity. Studies relating to high Arsenic concentration was also observed in Thoubal and Bishnupur district of Manipur [28], West Imphal district [10],and Imphal East, Imphal west, Thoubal and Bishnupur district [29].

Fluorine is the most electronegative element and it is the thirteen most abundant elements in the earth crust. Fluorine pollution is another major problem in India and its excessive intake beyond

1.5 mg/L causes a diseases fluorosis affecting more than half a million people in India and it is mainly due to its natural sources [30–32]. Studies relating to fluoride concentration have been carried out by various researchers, unfolded that a good number of the water samples collected in the various parts of Assam were contaminated with fluoride concentration above the permissible limit viz Kamrup district [33,34] Dibrugarh district [35], Karbi-Anglong district[36]. It was evident that the high fluoride concentration in various parts of Assam was due to geogenic origin and possible chemical fertilizers containing fluoride impurities.

Heavy metals are the greatest threat to human health as they get absorbed in the human body either from drinking water, food diet or by air. Studies on heavy metal contamination such as Cd, Fe, Hg, Cr, and Pb can cause kidney dysfunction and induced cancer risk. Prolonged exposure to heavy metals may also lead to disturb body's metabolism, internal imbalance and may alter central nervous system (CNS) function. Generally most of the heavy metals enter the water bodies through erosion or anthropogenic sources [37,38]. The heavy metal contamination in groundwater either from natural or anthropogenic sources has raised concerns all over the world due to its impact in public health[39]. Recent study on the soil contamination by heavy metal was investigated in the Silghit region of Assam due to the untreated jute mill solid waste affecting the soil quality of the region[40]. Contamination on the water bodies specially on ground water by heavy metals in major parts of Assam were also investigated viz. Dhemaji district contaminated with high concentration of Cr, Cu and Ni [41], East and west Karbi-Anglong district contaminated with high Fe [36], Darrang district contaminated with Mn and Cd [42]. Additionally, Guwahati city was found to be contaminated with high Fe, Cr, Cd, Pb and Hg [43]. Reports relating to metal contamination in Manipur state suggested the major problem of contamination in the different districts was due to Fe, Cu and Pb [10,44–46]. Relevant studies on high Fe concentration was also observed in Dimapur district of Nagaland exceeding two folds time their permissible limit[47] (See details in Table1-3).

Materials and Methods

The material used is a secondary data [48] identifying the patterns of various contaminants of Nagaland. The water samples collected in the used article is either from spring, pond and well water collected at a depth of 10-90 m. All the water samples were collected from the five districts of Nagaland seasonally (summer and winter) for a period of three continuous years.

Study Area

The studied area in the secondary data consist of the five district of Nagaland viz. Wokha, Tuensang, Zunheboto (Lumami), Kohima (Tseminyu) and Mokokchung (Ungma). Geographically the five districts are situated as shown in table 4.

Methods

The above secondary dataset was analyzed using various statistical procedures. Simple summaries like mean, median, mode, variance, range, skewness and kurtosis of the various physiochemical parameters were computed to ascertain the general level of abundance of the corresponding contaminants in the state. The above summaries also reveal important information useful in statistical modelling of the data.

Pairwise associations between the physiochemical parameters were measured using their correlation coefficients. Correlation coefficient (r) is expressed as:

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2 \times \sum(Y-\bar{Y})^2}}$$

The correlation coefficient scale can be seen in Table 3. It is important to note that the relationship between two sets of variables may be strong but not significant. Conversely, two variables may be significant but show weak or no correlation at all. Linear regression attempts to find the linear relationship between two variables by fitting a liner equation ($y = ax + b$) to the observed data.

The relationship between the physiochemical parameters is further explored by a principal component analysis (PCA). The correlation plots between the three significant principal components with these parameters are inspected. These plots reveal various clusters among the physiochemical parameters. Finally, the observations from the districts are subjected to a factor analysis (FA). The analysis reveals two distinct identifiable latent factors, and two well separated clusters among the districts. Statistical analysis was done using IBM SPSS 25 (Statistical Package for the Social Sciences) and R software version 4.1.2. More details about the PCA and FA can be found in [49].

Results and Discussion

It is observed from the secondary data of (Tiakaba et. al.) that the physiochemical parameters were collected from five districts of Nagaland and the various physiochemical parameters which were analyzed for three years seasonally. Then the values of the various parameters were compressed to their mean value manually for further statistical analysis as shown in Table 4. Based on the mean observation Table 6 indicates the presence of low pH and high concertation of Fe, Pb and Cu according to BIS standards. After the conversion to their mean (Table 4), the characteristic statistical values were also calculated using the IBM SPSS 20.1 statistical software as shown in table 5. Results obtained from descriptive statistical analysis (Table 5) reveals the presence of high concentration of Cu and Pb as per the permissible limit. Herein, the high concentration of Cu and Pb could possibly be explained by the presence of mineral deposition embedded in the earth crust or geogenic composition in the region. In addition, anthropogenic activities have very little influence over the presence of high concentration of Cu and Pb.

The correlation coefficient values for different water quality parameters are shown in table 6. The correlation study among the various parameters were calculated and the values indicated very strong positive relation observed between the concentration of EC and TDS (*r= 0.971/1.000*), Ni and TDS (*r=0.927/1.000*), Ni and EC (*r=0.933/1.000*). A high positive relationship among trace metals was observed between the concertation of Cu and Zn (*r=0.959/1.000*), and Fe and Cd (*r=0.961/1.000*). The positive or negative correlations between trace metals in different compartments depend on environmental/ geographical factors such as biological activities, chemical composition, and physical features which occurs in the natural aquatic habitats or surrounding. Moreover, the release of pollutants either by natural process as well as anthropogenic activities has very strong impacts on the metal's concentration and distribution in the aquatic environment. Other factors could be explained by the presence of soil organic matter which seeps into the aquatic environment later contributing and controlling the bioavailability, mobility and bioaccumulation of heavy metals It is important to note that correlation values between variables cannot conclusively prove causation during interpretation of correlation coefficient values, as it gives only a degree of relationship between variables.

DO is the amount of gaseous oxygen (O_2) dissolved in water. Out of the 15-correlation coefficient value, DO show a strong correlation with total hardness (*r=0.811/1.000*) and COD (*r= 0.698/1.000*) with a strongly negative correlation with Fe (*r= -0.737/1.000*) and Cd (*r= -0.866/1.00*). DO also showed relatively moderate relationship with EC, TDS and COD along with a weak and negative relationship for majority of the heavy metals except for Ni (*r=0.503/1.000*), and As (*r= 0.594/1.000*). pH as such, is a very decisive variable to study the lessening of heavy metals concentration in solution due to formation of precipitates. Herein, pH showed a high positive relation with As (*r= 0.836/1.000*), weak and moderate relationship with Ag (*r= 0.170/1.000*), Ni (*r= 0.350/1.000*), and Mn (*r= 0.554/1.000*). In addition, pH also showed very strong negative relationship with other metal \ in the order of negative correlation values Fe > Zn > Cu > Cd >Pb.

BOD showed a quantitative strong relationship with EC (*r=0.750/1.000*), TDS (*r=0.718/1.000*), weak relation with DO (0.394) and a negative relationship with pH (*r= -0.425/1.000*). As per the correlation value, BOD showed positive relationship with all the parameters, except for Mn, it showed a strong negative relation (r= *-0.405/1.000*). The values for total hardness (TH) showed a strong relationship with EC (*r=0.703/1.000*), TDS (*r=0.710/1.000*), DO (*r=0.811/1.000*), COD (*r=0.647/1.000*), Mn (*r=0.718/1.000*), Ni (*r=0.793/1.000*) and a moderate relationship with As (*r=0.513/1.000*). Additionally, a weak correlation and negative correlation for metal with the maximum negative value was observed for Cd (*r= -0.670/1.000*) and Fe (*r= -0.593/1.000*). Also, the relationship between COD and heavy metals showed quiet a positive degree of relationship with Cu (*r= 0.600/1.000*), Ni (*r= 0. 603/1.000*) and Zn (*r= 0.582/1.000*). However, the negative relationship was also observed with Fe, Cd and Pb which is in the order as: Fe (*r= -0.045/1.000*)> Cd (*r= -0.282/1.000*) > Pb (*r= -0.017/1.000*).

The observed correlation values among heavy metals indicates 17 out of 36 values showed negative relationship with maximum negative relationship between As and Zn (*r= -0.792/1.000*). Majority of the positive correlation values showed weak and moderate correlation as such between Pb and Zn (*r= 0.102/1.000*), Cd and Zn (*r= 0.300/1.000*), Ag and As (*r= 0.408/1.000*), Cu and Fe (*r= 0.365/1.000*), Ag and Ni (*r= 0.362/1.000*), Fe and Zn (*r= 0.540/1.000*), Mn and Ni (*r= 0.536/1.000*). In addition, As showed negative relation with all the other metal except for Mn (*r= 0.165/1.000*), Ag (*r=0.408/1.000*) and Ni (*r=0.492/1.000*). Strong positive relationship was also observed between Pb and Fe (*r= 0.686/1.000*), Pb and Cd (*r= 0.749/1.000*), Ag and Pb (*r= 0.601/1.000*). Pb only showed negative relation with As (*r= -0.258/1.000*) and Cu (*r= -0.178/1.000*). Interestingly, Ni showed no negative relation with the physiochemical parameters, while Cd showed the most negative relation with the physiochemical parameters (pH, EC, TDS, DO and COD). Also, among all the metal, TDS showed negative relation with Cd (r= *-0.090/1.000*).

Factor analysis is an important statistical tool that strives to compute variables and explain the extent of correlations among numerous outcomes from various pollutant which possibly explain the result as one or more underlying factors. The obtained factor analysis from Table 6 shows interconnected results between variables as shown in Fig 1a- 1c. Herein, pH and Arsenic show close relationship. The presence of arsenic in water bodies is mostly explained by geogenic origin. Nonetheless, the relationship could extent and variably explain the existence of high As occurs on high pH value which is well-established by various research finding. The relationship between Cu and Zn closeness which is mostly by the presence of Zn and Cu in the soil or mineral form. Additionally, the relationship between Fe and Cd was could also be ascertain through geogenic origin. The close relationship between DO and TDS indicate high TDS with low DO. The levels of changes between these parameters potentially act as an index to eutrophic activity in the water bodies. Also, very strong association between TDS and EC was obtained. TDS concentration primarily describes the presence of small amount of organic matter and inorganic salts in water and EC measures the water capacity to conduct electrical current. The sources of material in EC and TDS are either from geological condition of water or soil or by anthropogenic human activities.

Factor analysis in Fig. 1d results from principal component analysis of 16 variables indicate the MR2 (V4 - *Kohima district*) shows total deviation from the other four districts MR1 (V1, V2, V3, V5). It may be understood that the analysis results possibly could establish that increase population and rapid urbanization increases demand in the supply chain leads to greater waste generation. The presence of mineral deposition embedded in the earth surface crust or geogenic composition in the region can also be a key factor. Anthropogenic activities by humans with increasing urbanization cannot be ruled out as it is the major component towards any sources of pollution. Unethical and improper dumping of waste and human excreta in the area have been identified till today. In addition, Comparatively, the other four districts have lesser population density which might possibly could resulted the deviation of MR4 with the rest. Another factor may be due to the nature of mineral composition in the area occurred through geogenic origin which could have entered the natural habitat via natural calamities, floods, landslides etc.

Conclusion

Water makes up as an integral part for human survival, industrial, domestic household and agricultural activities. The human pressure on the natural habitat has severely affected the stability and quality of water. As per Nagaland, there is a mass knowledge gap on water related problems and its ill effects among locals which have not been identified to this extent. Although all 12 districts of Nagaland are still in the developing and growing state, but the extent of water pollution and scarcity are clearly being seen as of today. Majority of the perennial streams in this data shows high concentration of Cu and Pb primarily due to geogenic origin. Also, results from the factor analysis suggest the total deviation of V4 (MR2) from the other four districts (V1, V2, V3, V5). Such deviation could have been led by rapid urbanization and also due to geographical features, and geogenic nature of the earth's mineral composition. Thus, severely affected sources of water bodies are in much need for continuous monitoring and documentation to avoid spread of various ailments. Through this article, the importance of neighboring northeastern states of India which shares its boundary with Nagaland can possibly give an insight in the water pollution due to similarities in the geographical features. Additionally, using statistical method on secondary based data from research articles of Nagaland can justify the behavior of contamination level and how each district or region vary with the other.

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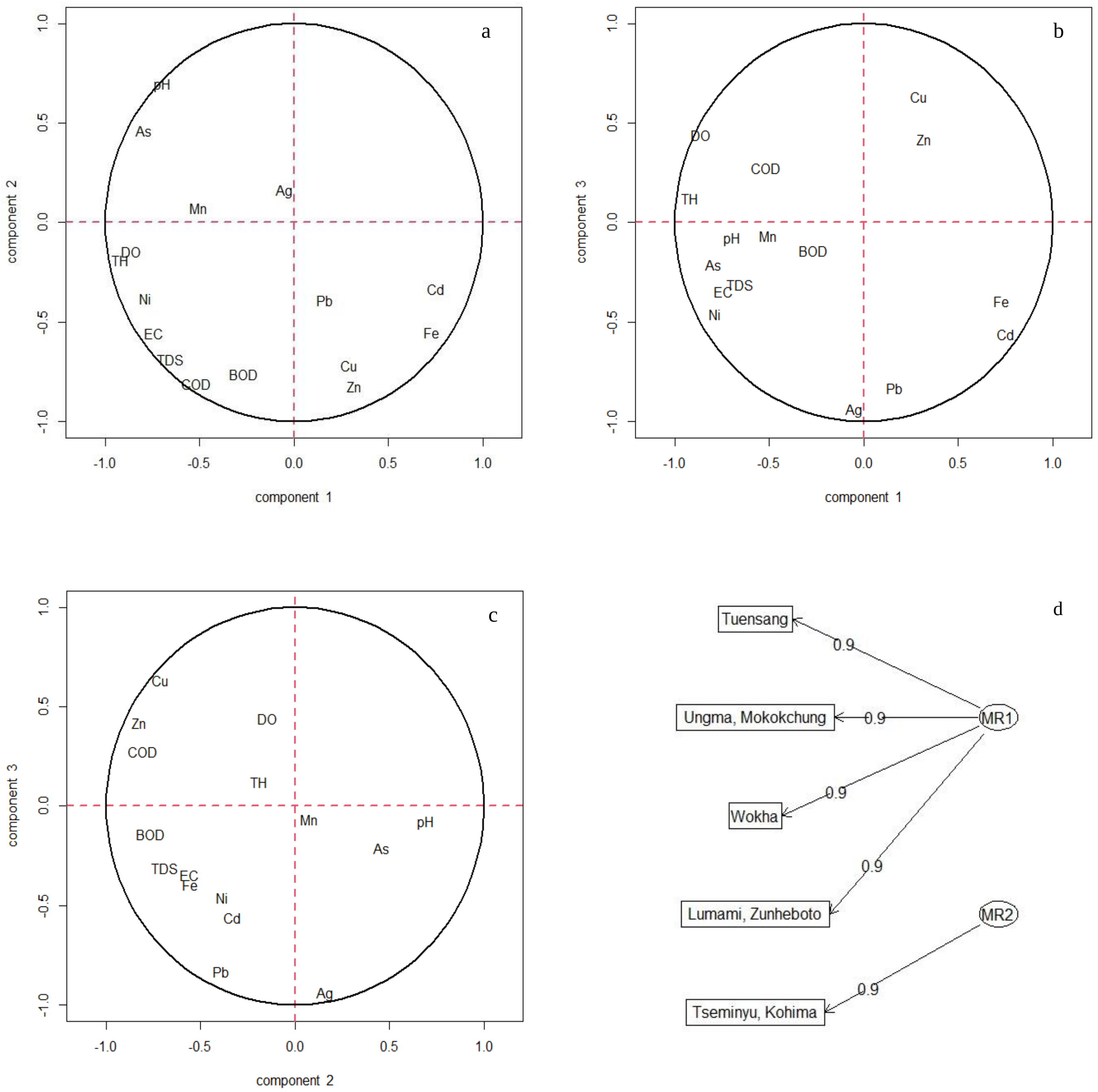

Figure 1: Results of clustering based on PCA and FA. Figures (a), (b) and (c) shows the cluster based on the correlations between the physiochemical parameters with the pair of principal components (1,2), (1,3) and (2,3) respectively. Figure (d) uses a two-component factor model to cluster the districts. Here MR1 and MR2 are the two latent components which explain the differences between the district clusters.

Table 1: Comprehensive study of water pollution in the state of Assam. Manipur and Nagaland

Sampling area	Major Sources of Contamination	Major Pollutants	Reference
Ledo-Margherita, Assam	Anthropogenic (coal field)	As	6
Ledo-Margherita, Assam	Anthropogenic (coal field)	Pb, DO, EC, TDS, Fe, Sulphate	8
Golaghat district, Assam	Anthropogenic	E. coli and faecal coliform	16
Dibrugarh district, Assam	Anthropogenic	Faecal coliform	14
Barak river, Assam	Anthropogenic	Faecal coliform pseudomonas	15
Lakhimpur district, Assam	Anthropogenic	As & Fe	26
Brahmaputra and Barak Flood Plain, Assam	Geogenic origin	As	24
Jorhat district, Assam	Geogenic origin	As	23
Sonitpur, Nagaon, Kamrup, Nalbari and Darrang	Geogenic origin	As	27
Golaghat district, Assam	Geogenic origin	As	25
Jorhat district, Assam	-	As	22
Silghit region, Assam	Anthropogenic	Heavy metals	40
Kamrup district, Assam	Geogenic origin	Fluoride (F^-)	34
Lakhimpur district, Assam	Geogenic origin	As, Fe and F^-	21
Dibrugarh district, Assam	Chemical Fertilizers (Anthropogenic)	F^-	35
Kamrup district, Assam	Geogenic origin & Anthropogenic	Fe, F^-, nitrate	33
Darrang District	-	Mn and Cd	42
Dhemaji district, Assam	Anthropogenic	Cr, Cu and Ni	41
East Karbi-Anglong district, Assam	Geogenic origin	Fe and F^-	36
Hamren sub-division Karbi-Anglong district, Assam	Anthropogenic	COD & E-Coli	17
Imphal East, Manipur	Geogenic origin & Anthropogenic	Fe, Cd & Pb	44
Imphal, Manipur	Anthropogenic	Turbidity & Alkanity	9
Imphal, Manipur	Geogenic origin	As, Fe, Mg & Ca	45
Imphal, Manipur	Anthropogenic	BOD	12
Imphal, Manipur	Anthropogenic	Cl^-, Total hardness, Turbidity & Na^+	11
Imphal, district	Geogenic origin	Fe	46
Imphal west, Manipur	Anthropogenic	Fe, Cl^-, Na^+, As, EC, TDS & Sulphate	10
Thoubal & Bishnupur district, Manipur	Geogenic origin	As	28
Imphal east & west, Manipur	Geogenic origin	As	29
Mangkolemba region Mokokchung district, Nagaland	Anthropogenic (Coal Mining)	pH, EC, TDS, Sulphate	7
Dimapur district, Nagaland	-	Fe, K^+ & Na^+	47

Table 2: Coordinates of Various districts of Nagaland

Sl. No.	District	Latitude	Longitude	Area (in km^2)
1	Wokha	26.10 N	94.27 E	1628
2	Tuensang	26.28 N	94.83 E	2536
3	Lumami, Zunheboto	26.20 N	94.47 E	1255
4	Tseminyu, Kohima	25.93 N	94.23 E	1463
5	Ungma, Mokokchung	26.33 N	94.23 E	1615

Table 3: Correlation coefficient scale

r = +1	**r = 0.8-0.99**	**r = 0.6-0.8**	**r = 0.4-0.6**	**r = 0.2-0.4**	**r = 0-0.2**	**r = 0**	**r = -1**
Perfectly positive correlation	Very strong correlation	Strong correlation	Moderate correlation	Weak correlation	Very weak correlation	No correlation	Perfectly negative correlation

Table 4: Physicochemical parameters and trace elements of five districts of Nagaland with their mean value

Sampling Distri	pH	EC (µS/Cm)	TDS mg/L	DO mg/L	BOD mg/L	COD mg/L	Total Hardness as CaCO3 mg/L	Ag (mg/L)	As (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Cd (mg/L)	Mn (mg/L)	Zn (mg/L)	Ni (mg/L)
Wokha	6.49	507.5	321.5	16.45	3.25	80.5	57.2	0.0005	0.0005	0.165	0.455	0.21	0.0015	0.145	1.33	0.0065
Tuensang	6.85	590	298.5	18	3.3	81	59.15	0.0005	0.001	0.14	0.18	0.025	0.0005	0.075	0.98	0.006
Lumami, Zunheboto	7.45	288.5	149	17	3.15	78	59.2	0.0005	0.001	0.06	0.1	0.06	0.0005	0.165	0.615	0.005
Tseminyu, Kohima	6.42	67.5	36	15.65	3.2	77.5	40.9	0.0005	0.0005	0.14	0.415	0.07	0.0015	0.045	1.025	0.001
Ungma, Mokokchung	6.96	515	255.5	16.1	3.25	78	50.75	0.001	0.001	0.03	0.365	0.21	0.0015	0.09	0.56	0.0065

Table 5: Descriptive statistics of various water parameters

Pollutants	pH	EC (μS/Cm)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TH (mg/L)	Ag (mg/L)	As (mg/L)	Cu (mg/L)	Fe (mg/L)	Pb (mg/L)	Cd (mg/L)	Mn (mg/L)	Zn (mg/L)	Ni (mg/L)
Mean	6.834	393.70	21.100	16.64	3.230	79.00	53.440	0.0006	0.0008	0.10700	0.303	0.1150	0.0011	0.1040	0.90200	0.005
Std Error (mean	0.185	95.83	53.061	0.405	0.02500	0.724	3.495	0.0001	0.0001	0.0261	0.0692	0.394	0.0002	0.022	0.1420	0.001
Median	6.850	507.83	255.50	16.450	3.250	78.00	57.200	0.0005	0.001	0.1400	0.3650	0.070	0.0015	0.090	0.9800	0.006
Mode	6.42	67.5	36.0	15.65	3.25	78.00	40.90	0.0005	0.001	0.14	0.100	0.210	0.0015	0.045	0.560	0.0065
Std deviat	0.413	214.28	118.64	0.9065	0.057	1.6202	7.816	0.00022	0.00027	0.05848	0.1547	0.883	0.00054	0.0498	0.317	0.0023
Variances	0.171	45917.8	14077.4	0.822	0.003	2.625	61.102	0.000	0.000	0.003	0.024	0.008	0.00	0.002	0.101	0.00
Skewness	0.719	-1.061	-0.917	0.798	-0.405	0.588	-1.362	2.236	-0.609	-0.611	-0.570	0.440	-0.609	0.214	0.222	-1.881
Kurtosis	-0.01	-0.107	-0.557	0.302	-0.178	-2.898	1.088	5.000	-3.333	-2.259	-2.266	-3.033	-3.333	-1.997	-1.339	3.558
Range	1.03	522.5	285.5	2.35	0.15	3.5	18.30	0.005	0.0005	0.135	0.335	0.185	0.001	0.120	0.770	0.0055

Table 6: Correlation coefficient of various water parameters

	pH	EC	TDS	DO	BOD	COD	TH	Ag	As	Cu	Fe	Pb	Cd	Mn	Zn	Ni
pH	1															
EC	0.140	1														
TDS	0.017	0.971	1													
DO	0.434	0.598	0.523	1												
BOD	-0.425	0.750	0.718	0.394	1											
COD	-0.226	0.746	0.807	0.698	0.744	1										
TH	0.556	0.703	0.710	0.811	0.189	0.647	1									
Ag	0.170	0.316	0.240	-0.333	0.169	0.345	-0.192	1								
As	0.836	0.452	0.257	0.594	0.080	0.000	0.513	0.408	1							
Cu	-0.741	-0.042	0.108	0.122	0.352	0.600	-0.039	-0.736	-0.710	1						
Fe	-0.850	-0.109	0.024	-0.737	0.242	-0.045	-0.593	0.224	-0.779	0.365	1					
Pb	-0.256	0.332	0.433	-0.521	0.161	-0.017	-0.060	0.601	-0.258	-0.178	0.686	1				
Cd	-0.697	-0.194	-0.090	-0.866	0.080	-0.282	-0.670	0.408	-0.667	0.107	0.961	0.749	1			
Mn	0.554	0.237	0.335	0.225	-0.405	0.139	0.718	-0.157	0.165	-0.199	-0.326	0.254	-0.293	1		
Zn	-0.792	0.046	0.233	-0.014	0.365	0.603	-0.022	-0.602	-0.792	0.959	0.540	0.102	0.300	-0.074	1	
Ni	0.350	0.933	0.927	0.503	0.473	0.582	0.793	0.362	0.492	-0.235	-0.174	0.458	-0.197	0.536	-0.097	1