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Trace Elements Concentration in Domestic Groundwater Wells in Northern Parts of Kelantan, Malaysia

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Abstract. Groundwater is one of the major alternatives of freshwater supply in rural as well as in urban areas in Kelantan. The need for groundwater has been rising day by day for irrigation purposes. The degree of trace elements pollution and the suitability of groundwater for drinking purpose were assessed through analysis of 32 groundwater samples of shallow aquifer. A total of 15 trace elements investigated includes As, Pb, Sr, Ba, Mn, Co, Ni, Cu, Cd, Fe, Zn, Cr, B, Se, and Al. The study reveals that most of the samples analysed contain marginally low concentrations of trace elements. The majority of toxic elements (As and Pb) are found to be in minute quantities and thus assumed to be inattentive in the wells. The concentration of all the elements except Fe and Mn were found far well within the permissible limits of WHO, thus pointing to the unpolluted source of water supply in the area. The concentration of Fe is higher in eight samples whereas Mn is on the higher side in twelve samples during post-season. Overall, all the elements show higher concentrations during post season owing to the less intensity of rainfall. Overall, the water in the area is safe for various purposes, but the source and contamination levels of Fe and Mn needs to be evaluated in detail. Moreover, appropriate use of law and regulations and effective water management is required amid rising population to preserve the quality of this resource for future generations.

1. Introduction

Groundwater is one of the primary sources of freshwater widely used in field irrigation, agriculture, and other domestic purposes [1]. Groundwater resources are of often understood to be protected in nature as it is understood to be originated from the deeper setting in the subsurface [2[. Groundwater occurs below the water table settings in fissured and weathered portions of crystalline strata [3]. The groundwater system in any particular region has its signatures as a result of the chemical alteration of precipitates infiltrating into the subsurface and the aquifer [4]. The chemical alterations are influenced by several aspects, such as interaction with the soil system, the residence time in the aquifer, mixing with mineral, and others [5].

In Kelantan, most of the population relies on groundwater, especially in rural regions, and utilized for various purposes. Since the nature of groundwater to be protected by overlying strata, which infiltrates a considerable amount of pollutants before reaching the aquifer, it is often regarded as safe for domestic uses such as for drinking, agriculture, and irrigation purposes as well [6]. Therefore, groundwater, which serves for these purposes, should be clean and free from any harmful substances.

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Substances including chemicals, effluents from industrial discharge, toxic elements, as well as elevated concentrations of ion and trace minerals, may be dangerous if consumed in a prolonged time [7]. Thus, groundwater quality assessment, including trace elements and major ions investigation is essential to be conducted to assess the suitability of these resources for drinking, agricultural, and irrigation purposes. The present study focuses on trace element concentrations in shallow domestic groundwater wells and which is crucial to delineate the possible elements which exceeded the standard concentration, especially in drinking water.

2. Materials nad Methods

2.1 Study area

The present analysis is conducted in the northern part of Kelantan, covering four major districts of Tumpat, Pasir Mas, Kota Bharu, and Bachok. The study area is bounded by latitudes of north 5º 55" and 6º 15" and longitudes of east 102º 4" and 102º 25," which covers 1400 km^{2}restricted area. The sampling location for trace element concentrations is digitized using ArcGIS software (Figure 1). The area is mainly underlain by alluvial deposits of Quaternary age [8]. The study area shows a wet and dry climate with a maximum temperature of 32ºC during dry seasons. It also encounters annual rainfall throughout the year but higher at the end of the year, which is contributed by north-east monsoons from October to January.

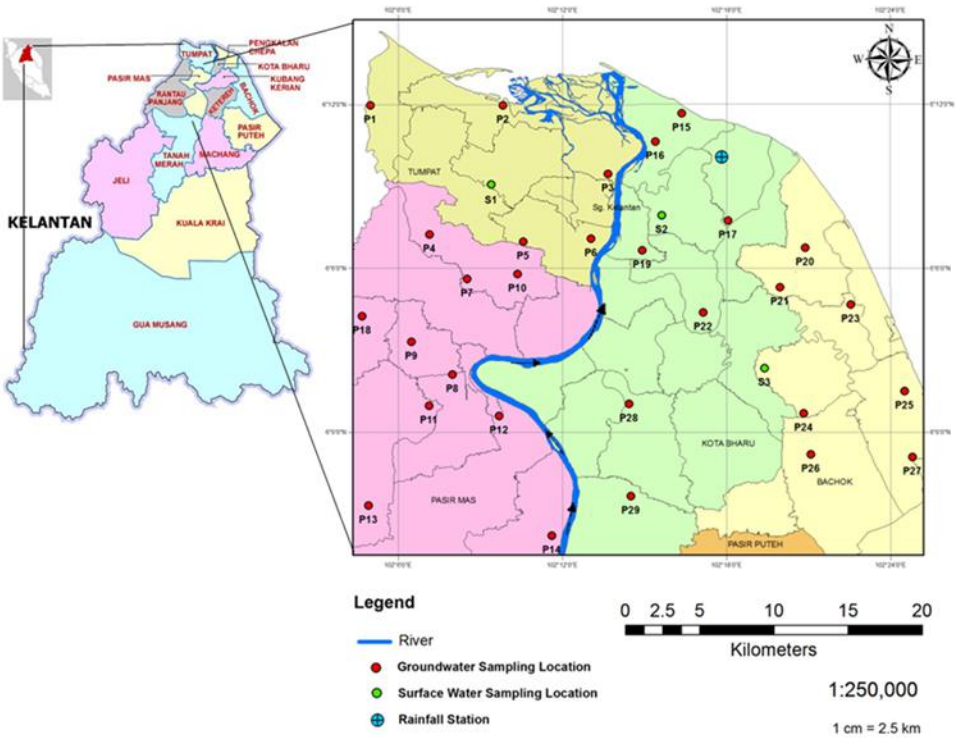

Figure 1. Map of study area showing the groundwater sampling locations

2.2 Sample collection

A total of 32 locations were identified for groundwater sample collections in the study area. Samples were collected in pre-season and post-season in the years 2015 and 2016respectively. The samples were collected from first aquifers uniformly, and borehole pumps using 1liter nitric acid cleaned polyethylene containers. For trace elements analysis, the sample bottles were soaked and rinsed with groundwater samples at sampling time. The trace element concentrations were analyzed in the

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Malaysian Nuclear Agency using instrument Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

3. Results and Discussions

The analytical concentration of trace elements distribution in the study area are tabulated in Table 1, Table 2 and Table 3 (please refer in appendix). Iron is an element that is fundamentally important in the human body. Elevated concentrations of iron in groundwater may result in poor taste, staining of paint, as well as surface corrosion in the underground pipe system [2]. On the other hand, deficiency of iron in the biological system may cause diseases such as anemia, a common problem [9]. Iron concentration in the study area (Figure 2) ranges from 0.0008 mg/l to 0.324 mg/l during pre-season, but sample P28 show higher than the maximum permissible limits (0.3 mg/l).

In contrast, during post-season, the iron concentration ranges from 0.026 mg/l to 11.14 mg/l, with an average of 1.846 mg/l, significantly exceeding the permissible limit of iron in groundwater. The highest concentrations were marked in locations P27 reaching up to 11.14 mg/l. The samples with higher Fe values fall in the Kota Bharu district. The anthropogenic role in Fe contamination cannot be ruled-out keeping in view the older water supply structures and high population in Kota Bharu. Geogenically, under low pH conditions, interactions among oxidized Fe minerals and organic matter can lead to the dissolution of Fe2CO3 [10]. Reducing conditions strongly favor rise of Fe by removing dissolved oxygen [11].

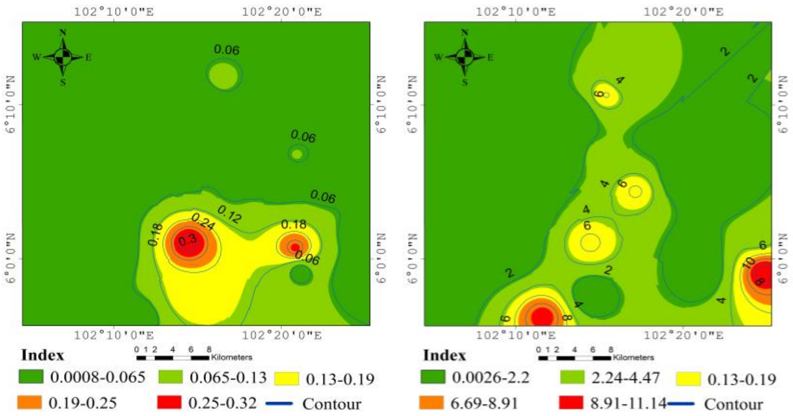

Figure 2. Iron distributions in groundwater samples during pre-season (left) and post-season (right).

Zinc concentrations range from 0.0008 mg/l to 1.431 mg/l during pre-season and 0.008 mg/l to 0.070 mg/l for post-season respectively. The concentrations of zinc in both seasons are lower than the standard permissible limit of 3 mg/l. Cadmium concentration ranges from 0.00001 mg/l to 0.0004 mg/l during pre-season and 0.00001 mg/l to 0.00046 mg/l for post-season respectively. All the groundwater samples are within the permissible limit of cadmium, which is 0.003 mg/l. Highly practiced agricultural activities can also lead to significant levels of cadmium, as pesticides are one of the important sources of cadmium [12, 13].

Chromium (Cr) concentrations range from as low as 0.0003 mg/l to a maximum of 0.0008 mg/l during pre-season. For post-season, the analysed concentration ranges from 0.0002 mg/l to 0.0005 mg/l. Chromium is essential quantities that are important for the normal secretion of insulin, which regulates glucose metabolism in the body system. However, excess intake of chromium may result in disorders such as hypertension.

The concentrations of copper (Cu) analysed ranges from 0.0005 mg/l to 0.0122 mg/l during pre-season and 0.002 mg/l to 0.182 mg/l for post-season with average values of 0.0031 mg/l and 0.027 mg/l respectively. The analyzed copper from groundwater is lower compared to 0.05 mg/l permissible limit. Aluminum concentration was recorded between 0.0006 mg/l and 0.168 mg/l during pre-season

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and 0.006 mg/l to 0.137 mg/l during post-season, while selenium concentrations range from 0.0009 mg/l to 0.0027 mg/l during pre-season and concentrations recorded less than 0.00005 mg/l to 0.00098 mg/l during post-season. The groundwater sample has a low concentration of aluminum but in two locations having values near to 0.2 mg/l standard limit of WHO. Aluminum presence in the groundwater is a possible process of dissolution of several substances, including clays and silicate compounds present in the strata [4, 2]. Boron concentrations were recorded from 0.004 mg/l to 0.0016 mg/l during pre-season and 0.003 mg/l to 0.030 mg/l of post-season which is lower compared to permissible limit of 0.3 mg/l.

Manganese occurrences are often attributed to the element iron in which they take place collectively and can be attained in various localities such as in groundwater, subsurface soil structures, as well as in rocks and sediments. Manganese concentrations are in the range of 0.001 mg/l to 0.006 mg/l during pre-season. For post-season, manganese concentrations vary from 0.0008 mg/l to 0.645 mg/l with an average 0.182 mg/l. During pre-season, the groundwater samples reported a normal concentration of manganese, which is fit for drinking purposes and not exceeding the acceptable limit. Alternately, for post-season, certain areas recorded elevated concentrations of magnesium element, which exceeded the 0.1 mg/l limit. In terms of cobalt, the concentrations are analysed in the range of 0.00001 mg/l to 0.0003 mg/l during pre-season. For post-season, cobalt concentrations ranges from 0.00004 mg/l to 0.0078 mg/l with average concentrations of 0.0016 mg/l. Cobalt during pre-season and post-season reported within 0.1 mg/l.

Nickel probably present in groundwater through corrosion of metal constituents from pipelines systems located on and below the surface [14]. Besides, piping systems that are old and corroded might also be a serious concern as the majority of citizens are not aware of these situations [15]. Based on that, it can be agreed that nickel is not contributing pollutants in the study area as its concentrations less than 0.0012 mg/l and 0.0067 mg/l for respective seasons are comparably lower compared to the permissible limit of 0.1 mg/l. Arsenic is found to be safe and harmless as its concentration is below 0.0055 mg/l mg/l compared to the WHO permissible limit of 0.01 mg/l.

Higher concentrations of lead in the drinking water supply are proven to be poisonous as it could damage the nervous system, thus affecting overall brain functions [12, 9]. Besides, abnormalities such as high blood pressure and hearing problems may also occur in the high consumption of lead [11]. Lead concentrations in the study area are observed to be very low, with the highest concentration of 0.0026 mg/l recorded during pre-season compared to the permissible limit of 0.01 mg/l. The average values of lead during pre-season are 0.0004 mg/l. For post-season, lead concentrations are noted from 0.0007 mg/l to 0.0298 mg/l with mean concentrations of 0.0038 mg/l. Therefore, lead concentrations in the study are safe for drinking and irrigation purposes in all samples except sample 18 slightly high. Barium concentrations in the study area are in the range of 0.0006 mg/l to 0.047 mg/l during pre-season while for post-season, the concentration ranges from 0.006 mg/l to 0.179 mg/l. The acceptance limit of barium is 0.7 mg/l.

Strontium ranges 0.0015 mg/l to 0.032 mg/l during pre-season. The mean concentration of strontium is 0.0132 mg/l below permissible limit of 0.07 mg/l while in post-season, strontium concentrations were between 0.002 mg/l to 0.137 mg/l with mean concentrations of 0.038 mg/l. Several groundwater locations collected during post-season indicated concentrations exceeding the permissible limit of strontium for drinking purposes. The differences in strontium values in groundwater during the seasonal analysis delineate a notable increase in the concentrations after the post-season. For anthropogenic bases, strontium could occur via ongoing agricultural activities that utilized fertilizers and other composites depending on the location of the sources close to poultry farm and cattle.

4. Conclusion

A study was carried out in parts of Kelantan to evaluate the current status of trace element concentration in shallow groundwater wells and its purpose for various uses such as for drinking and irrigation purposes. The distribution of various types of trace elements in groundwater sources has been discussed. All the elements except Fe and Mn show concentration far well within the permissible limit. The samples with higher Fe values mostly fall in Kota Bharu area owing to the oldest urbanized area. Elements including chromium (Cr), Cobalt (Co), Nickel (Ni), Arsenic (As), Cadmium (Cd), and lead, Pb are recorded in diminutive concentrations with few concentrations of lead, Pb is recorded <0.0001 mg/l.

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References
[1] Sarkar, A.A., Ali M. H.,& Hossain.(2002). Suitability of groundwater for irrigation use in four Upazilas of Magura district. J. Inst. Eng. Bangladesh, **29**: 93-100.
[2] Sadashivaiah, C., Ramakrishnaiah, C. R.,&Ranganna, G.(2008). Hydrochemical analysis and evaluation of groundwater quality in TumkurTaluk, Karnataka State, India. Intl. J. Environ. Research and Public health, **5**(3): 158-164.
[3] Rao, N. S. (2006). Nitrate pollution and its distribution in the groundwater of Srikakulam district Andhra Pradesh, India. Environ. Geol., **51**: 631-645.
[4] Muthulakshmi, L., Ramu, A., Kannan, N. (2012). Seasonal distribution of some heavy metal concentrations in groundwater of Virudhunagar District, Tamilnadu, South India. Electr.J. Environ. Agric. Food Chem., **11**(2): 32-37.
[5] Subba Rao, N. (2001). Geochemistry of groundwater in parts of Guntur district, Andhra Pradesh, India. Environ Geol, **41**:552–562.
[6] Islam, M.J., Uddin,S.M. H., Zaman, M.W., Mahmood, R. I., & Rahman, M. S. (2003). Toxicity assessment of groundwater in different aquifers of Khagrachari in Bangladesh. Asian J. Plant Sci., **2**: 257-260.
[7] Martinez, C. E., & Motto, H.L. (2000). Solubility of lead, zinc, and copper added to mineral soils. Environmental Pollution, **107**:153 – 158.
[8] Muqtada AK., et al. (2018) Evaluating the suitability of shallow aquifer for irrigational purposes in some parts of Kelantan, Malaysia. Bulletin of the Geological Society of Malaysia, **66**:45 – 53
[9] Dai, S., Ren, D., Shimin, M.(2004). The cause of endemic fluorosis in western Guizhou province, Southwest China. Fuel,**83**: 2095– 2098.
[10] Mondal, N.C., Singh, V.S., Puranik, S.C. and V.P. Singh (2010). Trace element concentration in groundwater of Pesarlanka Island, Krishna Delta, India. Environ. Monit. Assess., **163**: 215-227
[11] Muqtada A,K., et al. (2017) "Distribution Of Trace Elements In Groundwater Around Beris Lalang Landfill Bachok, Kelantan, Malaysia" , Asian Journal Of Water, Environment And Pollution, **14** (1) : 41–50.
[12] Khan, D.H.,&Frankland, B. (1983). Effects of cadmium and lead on radish plants with particular reference to the movement of metals through soil profile and plant. Plant and Soil, **70**:335-345.
[13] Buragohain, M., Bhuyan, B., &Sarma,P. (2010). Seasonal variation of lead,arsenic,cadmium, and aluminum contamination of groundwater in Dhemajidistrict,Assam, India. Environ. Mont. Ass., **170**(1-4): 345-351.
[14] Hunt, C. D., Shuler, T. R., &Multen, L. M. (2008). Concentration of boron and other elements in human foods and personal-care products. J. Am. Diet. Assoc, **91**: 558-568.
[15] Chen, A.S. C., Fields, K. A., Sorg, T. J., & Wang, L. L.(2002). Field evaluation of As removal

by conventional plants. J. Am. Water Works Assoc., **94**: 64-77.
[16] WHO. (2011). WHO Guidelines for drinking-water quality, 4th edition. World Health Organization, Geneva, Swizerland.

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Supplementary material

Table 1. Analytical Results of Trace Elements Concentration (mg/l) in the Study Area during Pre-Season

S/N	B	Al	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Se	Sr	Cd	Ba	Pb
P1	0.004	0.003	0.000	0.045	0.002	0.0001	0.0008	0.003	0.0008	0.0001	0.0016	0.0076	0.00001	0.013	<0.0001
P2	0.005	0.003	0.000	0.012	0.005	0.00007	0.0009	0.012	0.006	<0.0001	0.0012	0.0017	0.00013	0.0018	0.00002
P3	0.006	0.014	0.000	0.010	0.010	0.00002	0.0004	0.002	0.006	0.00043	0.0015	0.0074	0.00003	0.0094	0.0001
P4	0.005	0.013	0.000	0.005	0.004	0.00002	0.0004	0.001	0.008	0.00055	0.0014	0.0078	0.00003	0.010	0.00003
P5	0.006	0.000	0.000	0.030	0.001	0.00005	0.0004	0.002	0.0103	<0.0001	0.0015	0.0016	0.00005	0.0025	<0.0001
P6	0.010	0.002	0.000	0.005	0.001	0.00004	0.0006	0.002	1.431	0.0001	0.0012	0.0045	0.0003	0.0174	0.00001
P7	0.005	0.001	0.000	0.017	0.001	0.00038	0.0011	0.003	0.367	<0.0001	0.0014	0.002	0.00005	0.0029	<0.0001
P8	0.005	0.001	0.000	0.060	0.0008	0.00007	0.0003	0.002	0.0097	0.00006	0.0011	0.0063	0.00002	0.047	<0.0001
P9	0.009	0.125	0.000	0.003	0.025	0.00003	0.0005	0.009	0.3086	0.00050	0.0027	0.014	0.0001	0.012	0.00014
P10	0.004	0.003	0.000	0.012	0.0009	0.00004	0.0004	0.010	0.0082	0.00007	0.0014	0.0037	0.00002	0.014	<0.0001
P11	0.005	0.003	0.000	0.001	0.001	0.00001	0.0004	0.004	0.0066	0.00023	0.0013	0.0154	0.00003	0.011	0.00001
P12	0.004	0.005	0.000	0.003	0.001	0.00004	0.0003	0.005	0.0119	<0.0001	0.0013	0.0036	0.00004	0.013	0.00002
P13	0.004	0.002	0.000	0.008	0.002	0.00010	0.0002	0.004	0.0105	0.00004	0.0011	0.0081	0.00002	0.0347	0.00003
P14	0.004	0.068	0.000	0.002	0.035	0.00003	0.0003	0.006	0.0207	0.00007	0.0011	0.0324	0.00005	0.016	0.0002
P15	0.005	0.162	0.000	0.006	0.084	0.00003	0.0003	0.007	0.0204	0.00009	0.0011	0.029	0.00005	0.0143	0.0003
P16	0.005	0.063	0.000	0.006	0.034	0.00002	0.0003	0.004	0.0139	0.00004	0.0013	0.032	0.00006	0.0136	0.00014
P17	0.015	0.002	0.000	0.004	0.003	0.00002	0.0005	0.004	0.3206	0.00007	0.001	0.0016	0.00021	0.0006	0.00014
P18	0.005	0.004	0.000	0.002	0.002	0.00003	0.0003	0.001	0.0065	0.0004	0.0012	0.0255	0.00001	0.0322	0.00013
P19	0.004	0.082	0.000	0.001	0.048	0.00001	0.0002	0.0006	0.0053	0.00005	0.0011	0.0147	0.00001	0.0132	0.0001
P20	0.004	0.124	0.000	0.002	0.068	0.00002	0.0002	0.0006	0.003	0.00006	0.001	0.0139	0.00001	0.0127	0.0005
P21	0.016	0.002	0.000	0.015	0.003	0.00002	0.0006	0.0007	0.394	0.00007	0.0016	0.0016	0.00035	0.0008	0.0013
P22	0.004	0.084	0.000	0.001	0.053	0.00002	0.0002	0.0006	0.314	0.00006	0.0012	0.0134	0.00004	0.0122	0.0011
P23	0.004	0.075	0.000	0.003	0.042	0.00002	0.0003	0.002	0.0074	0.00008	0.0013	0.0288	0.00003	0.0133	0.00067
P24	0.005	0.168	0.000	0.002	0.271	0.00001	0.0002	0.0007	0.009	0.0001	0.0009	0.0143	0.00011	0.0092	0.0015
P25	0.004	0.054	0.000	0.001	0.034	0.00001	0.0003	0.0008	0.0051	0.00008	0.0009	0.0324	0.00009	0.0132	0.0008
P26	0.004	0.064	0.000	0.008	0.036	0.00001	0.0003	0.0015	0.0061	0.00008	0.0013	0.0285	0.00007	0.0138	0.0005
P27	0.016	0.001	0.000	0.003	0.003	0.00002	0.0007	0.0009	0.0925	0.00006	0.0015	0.0015	0.0004	0.0007	0.0015
P28	0.005	0.125	0.000	0.001	0.324	0.00002	0.0002	0.0005	0.0038	0.0001	0.0012	0.014	0.00003	0.0095	0.0023
P29	0.005	0.097	0.000	0.002	0.171	0.00002	0.0004	0.0007	0.0048	0.0001	0.0010	0.0141	0.00004	0.0090	0.0012

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Table 2. Analytical Results of Trace Elements Concentration (mg/l) in the Study Area during Post-Season

	B	Al	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Se	Sr	Cd	Ba	Pb
P1	0.006	0.066	0.0003	0.032	0.168	0.0003	0.0028	0.152	0.019	0.00084	0.00015	0.011	0.00046	0.021	0.0012
P2	0.005	0.030	0.0002	0.016	0.038	0.0012	0.0048	0.182	0.023	0.00007	0.00030	0.002	0.00032	0.006	0.0022
P3	0.007	0.137	0.0003	0.035	0.177	0.0002	0.0013	0.037	0.019	0.00077	0.00007	0.011	0.00003	0.017	0.0007
P4	0.004	0.023	0.0004	0.006	0.057	0.0001	0.0014	0.061	0.061	0.00004	0.00013	0.005	0.00003	0.026	0.0042
P5	0.005	0.020	0.0003	0.001	0.047	0.00007	0.0005	0.003	0.014	0.00014	0.00005	0.009	0.00002	0.017	0.0007
P6	0.005	0.066	0.0003	0.018	0.045	0.0013	0.0035	0.014	0.040	0.00012	0.00036	0.003	0.00011	0.036	0.0018
P7	0.003	0.014	0.0004	0.005	0.028	0.0001	0.0003	0.034	0.028	0.00008	0.00008	0.004	0.00005	0.022	0.0084
P8	0.004	0.017	0.0003	0.0008	0.048	0.00006	0.0004	0.003	0.012	0.00013	0.00014	0.009	0.00001	0.017	0.0007
P9	0.006	0.075	0.0004	0.037	0.184	0.0002	0.0013	0.007	0.026	0.00078	0.00024	0.011	0.00003	0.018	0.0018
P10	0.005	0.017	0.0002	0.061	0.050	0.0010	0.0032	0.020	0.029	0.00015	0.00040	0.009	0.00006	0.011	0.0020
P11	0.004	0.012	0.0004	0.005	0.026	0.0001	0.0014	0.032	0.032	<0.00005	0.00015	0.005	0.00003	0.105	0.0039
P12	0.005	0.017	0.0003	0.001	0.049	0.00004	0.0014	0.011	0.032	0.00014	<0.00005	0.024	0.00003	0.015	0.0019
P13	0.006	0.106	0.0003	0.042	0.034	0.0003	0.0017	0.028	0.031	0.00011	0.00018	0.008	0.00016	0.020	0.0298
P14	0.028	0.033	0.0003	0.595	9.958	0.0009	0.0018	0.010	0.009	0.00533	0.00017	0.130	0.00003	0.152	0.0007
P15	0.006	0.022	0.0002	0.394	2.605	0.0075	0.0053	0.044	0.020	0.00258	0.00027	0.013	0.00003	0.153	0.0046
P16	0.006	0.010	0.0002	0.278	6.123	0.0037	0.0057	0.007	0.024	0.00019	0.00008	0.065	0.00003	0.126	0.0019
P17	0.005	0.006	0.0002	0.304	1.540	0.0007	0.0006	0.010	0.036	0.00090	<0.00005	0.096	0.00025	0.023	0.0054
P18	0.007	0.018	0.0003	0.326	0.793	0.0017	0.0051	0.014	0.029	0.00107	0.00050	0.101	0.00014	0.024	0.0021
P19	0.007	0.036	0.0003	0.405	2.999	0.0078	0.0057	0.028	0.030	0.00296	0.00037	0.013	0.00012	0.163	0.0020
P20	0.028	0.007	0.0002	0.622	0.644	0.0010	0.0017	0.004	0.038	0.00012	0.00025	0.137	0.00021	0.162	0.0037
P21	0.008	0.078	0.0002	0.045	0.029	0.0004	0.0019	0.012	0.008	0.00016	0.00098	0.009	0.00005	0.009	0.0044
P22	0.005	0.011	0.0002	0.290	6.363	0.0038	0.0062	0.004	0.061	0.00021	0.00018	0.069	0.00016	0.132	0.0015
P23	0.004	0.011	0.0003	0.001	0.048	0.00009	0.0011	0.007	0.070	0.00011	0.00019	0.024	0.00046	0.018	0.0029
P24	0.006	0.011	0.0004	0.371	0.704	0.0009	0.0013	0.003	0.011	0.00089	0.00019	0.095	0.00002	0.021	0.0024
P25	0.009	0.024	0.0005	0.402	3.003	0.0077	0.0065	0.027	0.015	0.00302	0.00034	0.012	0.00002	0.179	0.0033
P26	0.009	0.072	0.0004	0.048	0.031	0.0004	0.0020	0.018	0.016	0.00011	0.00035	0.008	0.00008	0.016	0.0098
P27	0.030	0.012	0.0003	0.645	11.14	0.0010	0.0009	0.002	0.014	0.00576	0.00021	0.131	0.00004	0.168	0.0015
P28	0.008	0.010	0.0004	0.300	6.525	0.0039	0.0067	0.002	0.021	0.00024	0.00015	0.066	0.00006	0.119	0.0022
P29	0.008	0.013	0.0005	0.003	0.092	0.00005	0.0012	0.005	0.021	0.00012	0.00021	0.024	0.00008	0.018	0.0013

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Table 3. Comparisons of Trace Elements Concentration with W.H.O (2011) Permissible Limit.

Constituents	W.H.O (mg/l) (2011)	Concentrations during Pre-Season (mg/l)	Concentrations during Post-Season (mg/l)
Iron, Fe	0.3	0.0008 to 0.324	0.026 to 11.14
Zinc, Zn	3	0.0008 to 1.431	0.008 to 0.070
Cadmium, Cd	0.003	0.00001 to 0.0004	0.00001 to 0.00046
Chromium, Cr	0.05	0.0003 to 0.0008	0.0002 to 0.0005
Copper, Cu	1	0.0005 to 0.012	0.002 to 0.182
Aluminum, Al	0.2	0.0006 to 0.168	0.006 to 0.137
Selenium, Se	0.01	0.0009 to 0.0027	<0.00005 to 0.00098
Boron, B	0.3	0.004 to 0.016	0.003 to 0.030
Manganese, Mn	0.1	0.001 to 0.060	0.0008 to 0.645
Cobalt, Co	0.1	0.00001 to 0.0003	0.00004 to 0.0078
Nickel, Ni	0.02	0.0002 to 0.0012	0.0003 to 0.0067
Arsenic, As	0.01	<0.0001 to 0.0055	<0.00005 to 0.00576
Lead, Pb	0.01	<0.0001 to 0.0023	0.0007 to 0.0298
Barium, Ba	0.7	0.0006 to 0.047	0.006 to 0.179
Strontium, Sr	0.07	0.0015 to 0.032	0.002 to 0.137

The concentration of elements marked in red colour exceeds the WHO limit.