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Groundwater quality assessment of domestic shallow dug wells in parts of Tanah Merah district, Malaysia

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Abstract

Groundwater resources have become an important fresh water supply due to its increasing demands for agricultural, drinking and industrial uses. Groundwater is often contaminated by the process of industrial development and suburbanization that has gradually advanced over time without any concern for environmental consequences. The objective of this study is to analyse the groundwater quality of shallow dug wells in parts of Tanah Merah district by conducting quality assessment of groundwater using WHO and MHO guide lines. Groundwater samples were collected from dug wells uniformly spread out across the study area to investigate the major ion chemistry of the groundwater as well as physical parameter. The major ion being investigated are sodium, magnesium, calcium, potassium, sulphate, nitrate, chloride and bicarbonates. Various methods have been were employed to determine the major ions concentration in the samples such as atomic absorption spectrophotometer for cations, gravimetric method for sulphates, titration method for chloride and bicarbonates and colorimetric method for nitrate ion. From the analysed data's, most wells are safe for drinking purpose although quite a small amount of ion concentration has surpassed the permissible limit set by WHO and MOH. The graphical presentation of major ion chemistry aids in identifying two types of groundwater. Ionic species such as Na-K-HCO_3 and mixed type waters are likely to occur in the groundwater system. The analysed major ions concentrations indicates that majority of the shallow dug wells reported adequate or lower values compared to permissible limit which are safe and can be utilized for various domestic purposes including drinking. Several recommendations has been suggested to proliferate the groundwater quality such as strictly monitoring and supervising the dissipation of waste such as pesticides, industrial effluent and domestic sewage into the aquifer.

1. INTRODUCTION

Groundwater in Malaysia is a significant reserve that can supplement the growing demand of fresh water for various consumptions (Mohammed et al., 2009). Problems such as nutrients discharge level and added substances, leaching of nutrients, metals through macro pores as suspended compounds and sludge biological substance on the sorption deprivation are time and again not understood by numerous parties (Longe & Balogun, 2010; Mohamed et al., 2009). Several of the contaminations issues associated to these activities are extremely intricate, plus some are not well unstated (Asadi et al., 2010). In rural areas, the groundwater quality is affected by various land practises and waste disposal. One main source of groundwater contamination in the shallow aquifer is the improper storage of waste materials such as domestic and industrial effluents in excavations, such as pits or landfills and mines (Freifeld et al., 2009; Moayedi et al., 2011). Overload intake of these major ions via drinking water might possibly cause health blow on human beings in many countryside areas. A good and proper standard should be followed by the authorities in maintaining the quality of groundwater such as the desirable drinking limit as well as maximum permissible limit set by the World Health Organization and Ministry of Health.

For the past civilizations, dug well are common method utilized for fresh water abstractions which has been traditionally practised for over thousands of years (Muthulakshmi et al., 2012). Dug wells are described as shallow holes dug deeper towards the aquifer or water table. In Kelantan, particularly in rural areas, unprotected, exposed shallow dug wells are more common as it can be easily developed with minimal production cost and also the easiest method of getting fresh water supply. However, this type of well are easily contaminated from pathogens, domestic execrations from livestock and community and spilt water giving to its physical state of poorly constructed

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condition and close to subsurface contact (Wick et al., 2012). In this condition, these wells pose a serious health risk to the nearby community depending very much on the fresh water resources.

Drinking water can be described as water obtained by the community in an area which serves a specific purpose as a safe drinking water. The hydro chemical parameters of groundwater reveals a significant role in evaluating water quality which is suitable for drinking and other domestic purposes (Sadashivaiah et al., 2008). A proper water quality standard is issued by the related organization that serves as reference for the adequate concentration of ion in water so that it will be safe to be used as drinking water and other domestic purposes. The WHO have emphasized on the necessity for conserving groundwater quality standards by serving guidelines for drinking water quality parameters as well as to emphasis on public health awareness (WHO, 2011). Several analyses must be made in the field at the time of sampling. This is to, measure the how high or how low the contamination of the groundwater in a particular study area.

2. MATERIALS AND METHODS

2.1. Study area

The study area is a parts of Tanah Merah districts, Malaysia (Fig 1) covering an area approximately 25 km^2. It lies between latitudes 5° 46" and 5° 49" north and between longitudes of 101° 57" and 102° 00" east. Most of the villagers in the research area utilize groundwater as the main source for domestic purposes such as for drinking water, agricultural uses as well as economic purposes. Almost all of the houses in the study area are equipped with borehole and pump to aid in groundwater withdrawal purposes. Besides, some of the villagers also make use of hill water aside from groundwater resources. The topography of the study area is mostly flat and hilly surfaces besides low lying unit with mean elevation less than 40 meter.

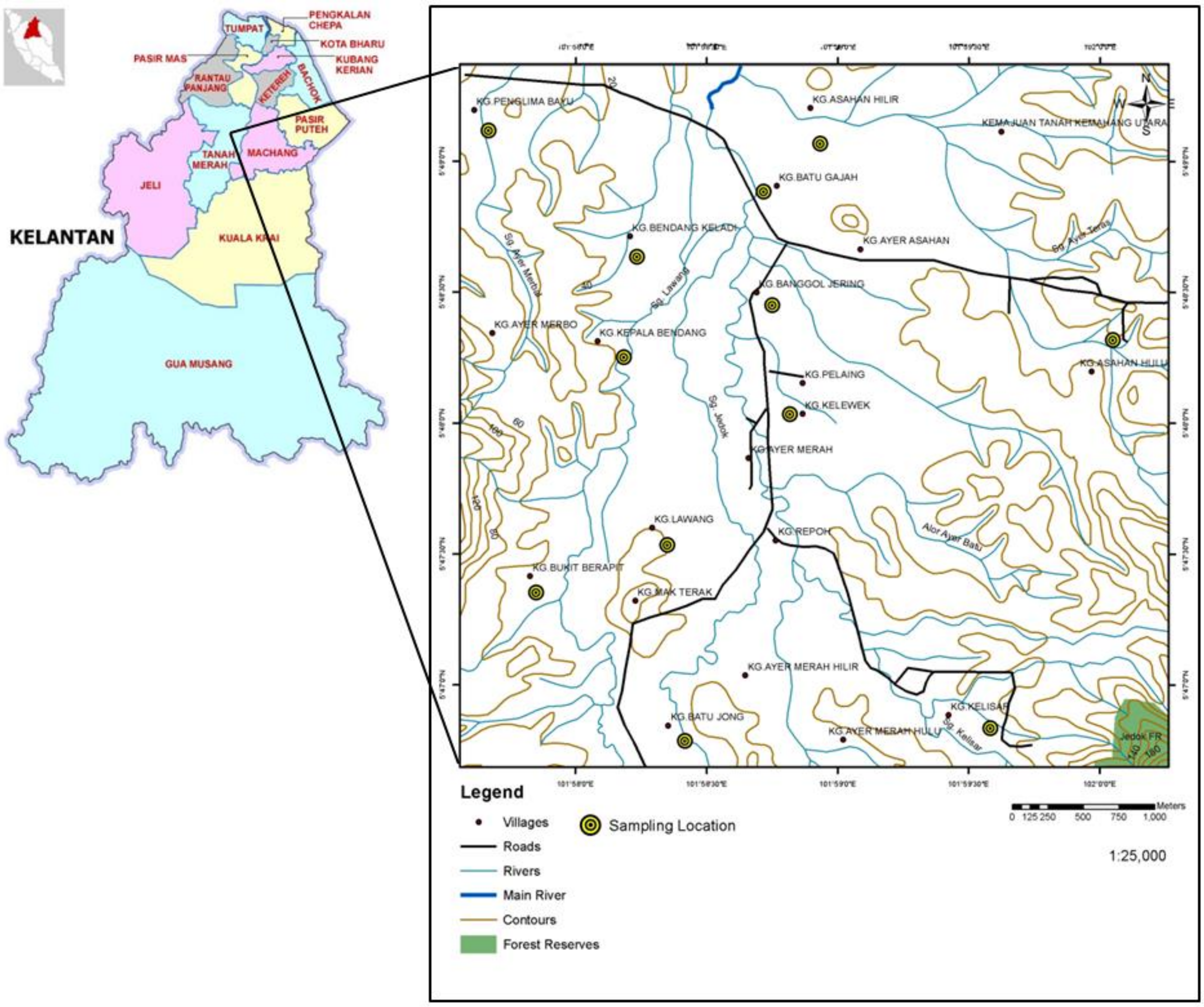

Figure 1: Sampling location map of the study area

Twelve groundwater samples from shallow dug wells were collected in one litre polythene bottles using bailer. The bailer is lowered into the wells using a set of cable attached to the end of it to raise the groundwater before being levered up. Before sampling, the bailer is thoroughly cleansed to avoid mixing of samples from other wells as to ensure precise analysis. In-situ parameter were recorded such as EC, TDS, temperature, water level and

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pH using potable water analysis kit. For laboratory analysis, atomic absorption spectrophotometer (AAS) were used to determine the concentration of the major cations including calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}) and potassium (K^{+}). For anion concentration, gravimetric method, titration method and colorimetric method were used to determine the concentration of sulphate, chloride and bicarbonate, nitrate and fluoride ions respectively.

3. RESULTS AND DISCUSSION

The hydrogeochemical study reveals that the quality of groundwater from shallow dug wells is suitable for drinking, agriculture and industrial purposes. Based on the assessment, the groundwater quality are tabulated and compared with standard drinking guidelines of WHO and MOH in Table 1. The distribution of concentrations are presented in the form of contours for several important parameters such as hardness, magnesium, nitrate and bicarbonate as these parameters are the crucial benchmark in assessing the suitability of groundwater for domestic purposes, and more importantly drinking purposes. Hence, these parameters needs to be monitored regularly and interpreted in details as to assess the suitability of groundwater for drinking purposes (WHO, 2011). It is observed that the groundwater from several shallow dug wells is of doubtful quality due to the presence of colour, odour and taste which are indications of pollution (Odukoya & Abimbola, 2010). The groundwater samples tested indicates that some spots in the study area may be infected with contaminants such as pesticide, agricultural waste, domestic waste, waste disposal facilities, industrial pollution.

Table 1: Range of standard drinking guidelines in comparison physicochemical concentration of groundwater samples collected from the study area

Well No.	Temp (^0C)	pH	EC (ηS/cm)	TDS (mg/l)	Hardness (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	F^- (mg/l)
W1	26.4	6.1	63.54	46.92	5.754	32.57	5.404	2.802	0.149	190.000	7.430	7.000	4.600	0.415
W2	27.1	6.0	241.23	173.76	3.566	227.2	852.0	0.577	0.043	260.000	16.120	8.000	13.966	0.302
W3	26.6	5.9	45.78	34.75	4.330	19.01	2.122	1.328	0.048	180.000	4.420	12.00	5.333	0.354
W4	29.4	5.9	113.21	82.54	5.101	1.066	4.622	1.149	0.056	640.000	12.630	4.000	3.734	0.377
W5	28.6	6.6	395.62	284.82	4.547	2.494	4.765	0.630	0.055	325.000	20.270	18.00	3.167	0.437
W6	27.8	6.9	79.10	59.94	4.652	1.626	9.480	0.557	0.068	247.000	16.840	4.000	7.808	0.443
W7	28.1	7.3	305.71	224.34	6.259	1.046	7.640	0.555	1.620	210.000	56.390	82.00	3.834	0.530
W8	33.4	6.1	52.59	38.31	1.440	0.744	3.667	0.773	0.120	335.000	3.765	25.00	6.767	0.642
W9	27.4	5.8	63.54	47.45	4.673	22.01	3.428	0.767	0.007	175.000	20.064	7.000	1.267	0.673
W10	28.9	6.3	181.67	132.06	3.211	17.55	0.705	0.457	0.006	235.000	8.720	23.00	5.435	0.657
W11	27.9	6.8	92.54	67.13	2.385	0.635	4.840	0.209	0.069	175.000	18.339	4.000	5.134	0.513
W12	25.3	7.2	86.61	65.18	3.438	24.63	4.114	0.518	0.077	160.000	7.210	8.000	8.100	0.434
Ranges	25.3-29.4	5.8 - 7.3	45.78-395.62	34.75-284.82	1.440-6.259	0.635-227.2	0.705-852.0	0.209-2.802	0.006 - 1.620	160-640	3.765-56.390	4.0-82.0	1.267-13.96	0.307 - 0.673
WHO (1993)		6.5 8.5		1000	500	200	30	200	150	380	250	400	50	1.5
WHO (2000)		6.5 9.5		1000	500	200	12	200	150	500	250	200	50	1.5
MOH (2000)		5.5 9.5		1000	500	200	30	200	150	500	250	250	10	1.5

The concentrations of hardness are recorded between 1.440 mg/l to 6.259 mg/l as shown in Fig 2 and classify as fresh water.

The average concentration of TDS value is 104.77 mg/l. The groundwater in the study area is classified as fresh water based on their respective classification according to TDS classification. The TDS in the study area could originate from mineral constituents dissolved from rocks and soils as well as material which are in solution in the aquifer (Willis, 2001).

The concentration of sodium ion in the study area ranges from 0.635 mg/l to 227.200 mg/l. Sodium ion has highly flowing ablility by which it can be mobile from one area to another area easily compared to potassium ion. However, excessive sodium ion in shallow aquifer not only affects the quality of groundwater as drinking water but it also produces the undesirable effects such as altering soil properties and reducing soil permeability. The stream water carrying the sodium ion could possibly seep into the groundwater wells resulting in high concentration of sodium ion in the groundwater samples.

Calcium ion concentration in study area varies from 0.209 mg/l to 2.802 mg/l. and it consider suitable based on calcium.

Potassium ion concentration obtained ranges from 0.705 mg/l to as high as 852.000 mg/l. Potassium is an important component mainly used as compost in crops and plantation. The potassium concentration in Well 2 in is presumably higher compared to normal concentration. This could be due to large agricultural activities on going in that region. The potassium ion used in the fertilizer is sturdily held by clay particles in the soil composition (Willis, 2001). Hence, rain water percolating downward the soil structure will leach out huge concentration of potassium ion held in the soil towards the water table region. The potassium ion will then circulate into the groundwater particles which eventually will seeps into well.

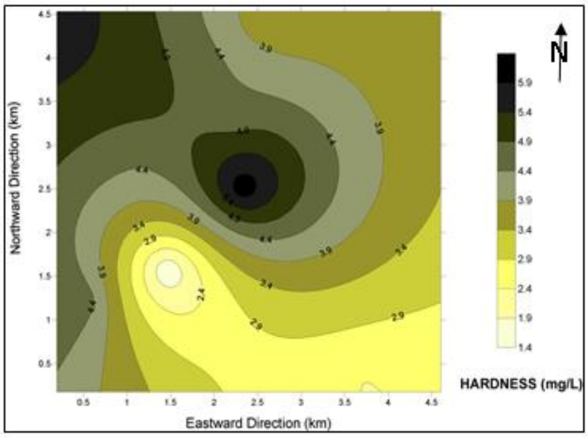

Figure 2: Distribution of hardness concentration in study area

The concentration of magnesium ion in the study area ranges between from 0.006 mg/l to 1.620 mg/l and distribution pattern as shown in Fig 3.

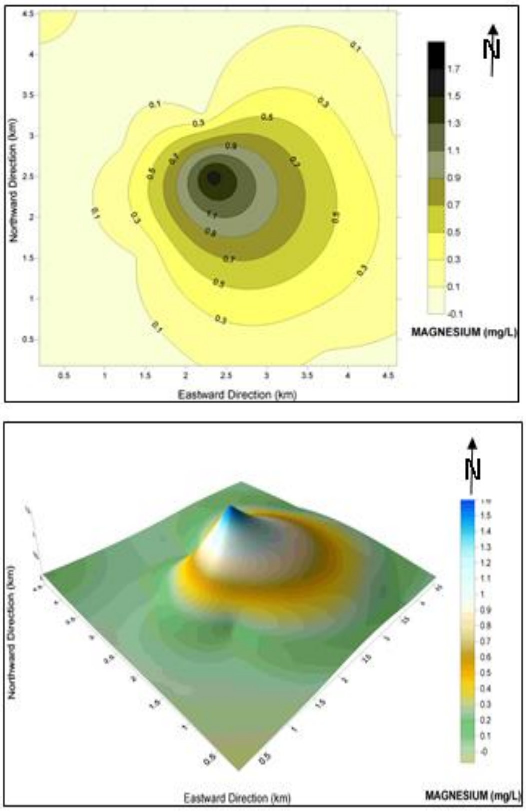

Figure 3: Distribution of magnesium concentration in study area

Nitrate ion, is generally present in groundwater as the end product of the aerobic decomposition of organic nitrogenous matter. Unpolluted natural waters usually contain only minute quantities of nitrate (Igbinosa & Okoh, 2009). Fig 4 shows the distribution of nitrate ion in the study area. Nitrate ion concentration in a particular area could rise due to presence of excess fertilizer or compost which is increasingly used in agricultural activities. The nitrate concentration variations correspond to the groundwater flow especially in paddy field area. Besides, high nitrate concentration could also be as a result of lower average temperatures, possibly due to increased evapotranspiration during post monsoon (Wick et al., 2012). Increased nitrate concentrations in groundwater can be a serious concern as it may represent a loss of fertility from overlying soil, resulting in eutrophication.

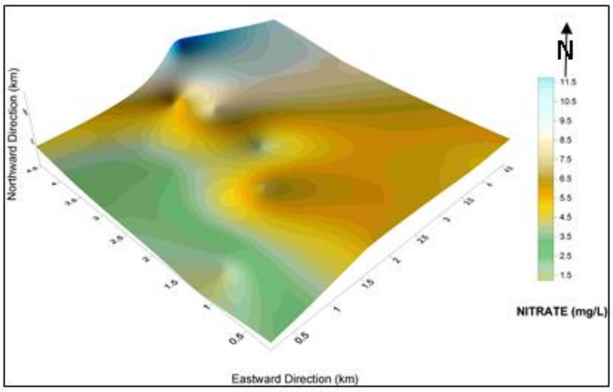

Figure 4: Distribution of nitrate of groundwater samples in parts of Tanah Merah district, Kelantan

The concentration of sulphate ion is in the range of 4.000 mg/l to 82.000 mg/l. The highest concentration of sulphate ion is in Well 7 reaching 82.000 mg/l. Sulphate ion occurs primarily in huge numbers of minerals as well as rocks. Sulphate can also be positively correlated with groundwater samples having higher nitrate ion concentration. Besides, the presence of sulphate ion in the groundwater well may also be due to geological factors which dissolved from rocks and soils containing gypsum, iron sulphides, and other sulphur constituent (Willis, 2001).

The groundwater well in the study area has chloride ion concentration ranging from 3.675 mg/l to 56.390 mg/l. The quality of groundwater for drinking water purposes in the study area is still below permissible limit since all the samples tested for chloride ion does not exceed the desired concentration. The range of bicarbonates concentration obtained in the study area, ranging from 160 mg/l to 640 mg/l. The highest concentrations of bicarbonates are observed to be in groundwater samples in Well 4, reaching 640 mg/l, as shown in Fig 5. The comparably high concentration of bicarbonates ion in Well 4 might possibly take place from oxidation of organic carbon. These findings have high variance with that of Tanah Merah districts where it has enormous igneous

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lithology noted to be releasing carbonates (Muthulakshmi et al., 2012).

The concentration of fluoride ion in the study area varies between 0.302 mg/l to 0.6733 mg/l. Fluoride content in groundwater originates primarily from the dissolution fluoride-rich minerals of the bedrock (Elango et al., 2003). A fluoride rich mineral includes fluorite, apatite, mica, amphiboles, and also clay (Kumar, 2012).

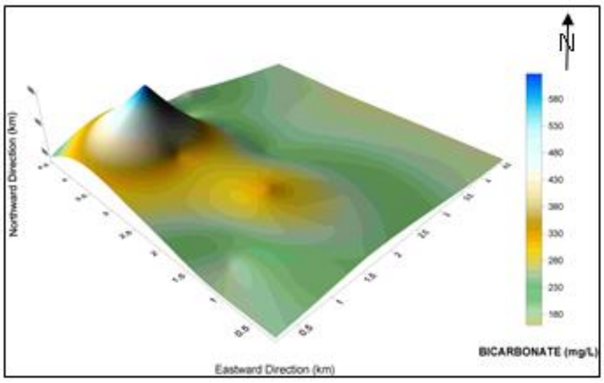

Figure 5: Distribution of bicarbonate of groundwater samples in parts of Tanah Merah district, Kelantan

The distribution series of various cations and anions can be interpreted with the help of certain diagram which clearly shows whether the division occur in equilibrium or otherwise. These diagrams which are able to assist in the data interpretation include Piper Trilinear Diagram and Langeliar and Ludwig Diagram. From the plotted data, it can be observed that most of the groundwater wells have higher concentration of sodium and potassium expressed in terms of percentages. Fig 6 shows the intersections containing high amount of points observed in the lower-middle side of the diagram or intersection of sodium + potassium + bicarbonate, Na+ + K+ + HCO3- type of groundwater facies.

Two groups of groundwater, characterized by distinct chemical compositions, had been identified on L-L diagram, shown in Fig 7, one major group that were classified into Na-K-HCO3- type and the other minor which categorized into mixed type.

4. CONCLUSION

The main objective of the study which includes groundwater quality assessment in parts of Tanah Merah district was successfully conducted and achieved. From the assessment, the concentration of major cations and anions in the groundwater samples are below the permissible limit and are suitable for drinking purposes. Nonetheless, few groundwater samples from shallow dug wells in Tanah Merah district have slightly exceed the standard limit and may cause health issues if consumed in a long period of time. The establishment of wells at suitable sites keeping the hydrogeology and urbanization pattern under consideration could prevent the groundwater from contamination. Avoiding pesticide pollution of groundwater is fairly simple and reduce pesticide use in an areas known to be recharge for groundwater.

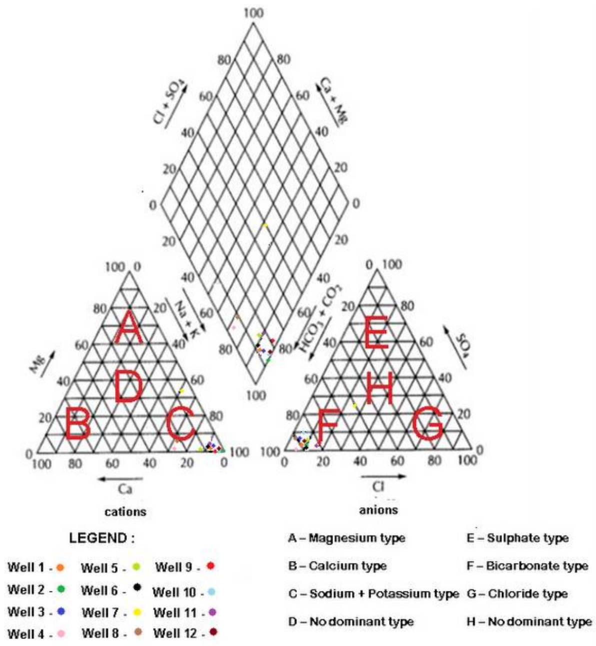

Figure 6: The distribution of ion in groundwater samples in parts of Tanah Merah District, Kelantan

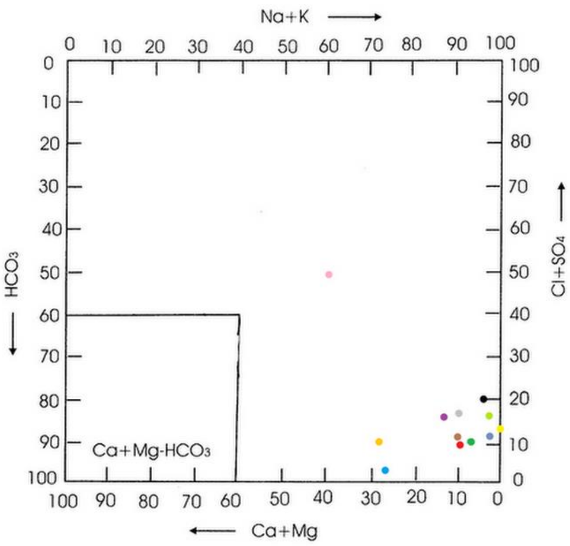

Figure 7: The distribution of ions in groundwater samples in parts of Tanah Merah District, Kelantan

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REFERENCES

Asadi, A., Huat, B. B. K., Hanafi, M. M., Mohamed, T. A., Shariatmadari, N., (2010). Physicochemical sensitivities of tropical peat to electro kinetic environment. Geoscience Journal, 14(1), 67-75.

Elango, L., Kannan, R., Kumar, M. S., (2003). Major ion chemistry and identification of hydrogeochemical processes of groundwater in a part of Kancheepuram district, Tamil Nadu, India. Journal of Environmental Geosciences, 10, 157-166.

Freifeld, B. M., Daley, T. M., Hovorka, S. D., Henninges, J., Underschultz, J., Sharma, S., (2009). Recent advances in well-based monitoring of CO2 sequestration. Energy Procedia, 1(1), 2277-2284.

Igbinosa, E. O., Okoh, A. I., (2009). Impact of discharge wastewater effluents on the physic-chemical qualities of a receiving watershed in a typical rural community, International Journal of Environmental Science and Technology, 6(2), 1735-1742.

Longe, E. O., Balogun, M. R., (2010). Groundwater quality assessment near a municipal landfill, Lagos, Nigeria, Research Journal of Applied Sciences, Engineering and Technology, 2 (1), 39-44.

Moayedi, H., Asadi, A., Moayedi, F., Huat, B. B. K., Chea, L. W., (2011). Optimizing stabilizers enhanced electrokinetic environment to improve physicochemical properties of highly organic soil. International Journal of Electrochemical Sciences, 6 (5), 1277-1293.

Mohamed, A.F., Yaacob, W. Z. W., Taha, M. R., Samsudin, A. R., (2009). Groundwater and soil vulnerability in the Langat Basin Malaysia. European Journal of Scientific Research, 27(4), 628-635.

Muthulakshmi, L., Ramu, A., Kannan, N., (2012). Seasonal distribution of some heavy metal concentrations in groundwater of Virudhunagar District, Tamilnadu, South India, Electr. Journal of Environmental Agricultural and Food Chemistry, 11(2), 32-37.

Odukoya, A. M., Abimbola, A. F., (2010). Contamination of surface and groundwater within and around two dumpsites. International Journal of Environmental Science and Technology, 7(2), 367-376.

Sadashivaiah, C., Ramakrishnaiah, C. R., Ranganna, G., (2008). Hydrochemical analysis and evaluation of groundwater quality in Tumkur Taluk, Karnataka State, India. International Journal of Environmental Research and Public Health, 5(3), 158-164.

Kumar, P. J. S., (2012). Assessment of fluoride contamination in groundwater as precursor for electro coagulation. Bull Environmental Contaminant and Toxicology, 1 (2), 8-12.

WHO, (2008). Nitrate and nitrite in drinking water. Background document for preparation of WHO guidelines for drinking water quality. Geneva, World Health Organization (WHO/ SDE/ WSH/ 03.04/114).

Wick, K., Heumesser, C., Schmid, E., (2012). Groundwater nitrate contamination: factors and indicators. Journal of Environmental Management, 111 (30), 178-186.

Willis, D. W., (2001). Hydrogeology Field Manuel, 2nd, Montana Tech of The University of Montana Butte, Montana, The McGraw-Hill Companies Inc., 87-231.

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