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DETERMINATION OF GROUNDWATER (HYDROCHEMISTRY) CHARACTERISTICS AND QUALITY ASSESSMENT FOR CONSUMPTION AND IRRIGATION PURPOSE IN LANGAT RIVER BASIN, SELANGOR

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Abstract

Evaluation of groundwater quality is very important as it is widely used for drinking and other day to day activities. Therefore, this study aims to monitor the groundwater quality for the safety of public health and plant. Groundwater samples were taken from fifteen (15) different wells and analysed for various physico-chemical parameters such as pH, temperature (temp), salinity (Sal), electrical conductivity (EC), total dissolved solids, (TDS), dissolved oxygen (DO) and turbidity (turb). Major ions in the study include anions (bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}) and nitrate (NO_3^-). While cations are calcium (Ca^{2+}) magnesium (Mg^{2+}) sodium (Na^+) and potassium (K^+). The pH values in most of the station are lower than the permissible range of (WHO and MOH) standard limit. The value ranges from 4.68-7.58 with an average of 5.94. The TDS ranges from 33 mg/l – 1698 mg/l with an average of 229.8 mg/l. Laboratory analysis were carried out in all the major ions listed above and Statistical analysis were conducted using SPSS version 25. Pearson correlation were analysed to identify the relationship of the parameters with each parameter. Anions dominance in the study area is $HCO3^- > Cl^- > SO_4^{2-}$. While the Cations dominance ions are $Na^+ > K^+ > Ca^{2+} > Mg^{2+}$. The results show that the groundwater is of Na+Cl-SO42- water type and the chemistry are controlled mainly by weathering of rock, agricultural activities, and evaporation. Piper diagram was used to identify the type of groundwater water in the study area the groundwater chemical composition is mainly K^+, Cl^-, and SO_4^{2-}. The suitability of groundwater irrigation use was determine through %Na Sodium adsorption ratio (SAR), Kelley's ratio, and Magnesium hazards (MH). The results indicated that 75% of the wells is suitable for irrigation.

***Keywords**: physico-chemical agricultural, groundwater quality, major ions, pollution, monitoring and drinking purposes.*

INTRODUCTION

Groundwater is the water found underground in cracks, spaces in soil, sand and rocks. It is stored in aquifer and moves slowly through geologic formations of soil, sand and rocks. In this manner, water quality is a fundamental segment of the common habitat and is considered as the primary factor for controlling natural wellbeing and potential risk to surrounding of ecosystem and environment (Isa et al., 2015). The chemistry of groundwater has much influenced by rock material, soil and pollutant sources (Dev et al., 2018, Zenk et al. 2017). Groundwater is important resources for socioeconomic activities, not only in Malaysia but world at large. Studies on groundwater geochemistry has what it take to answer some basic question regarding the characteristics and behaviour of the processes that concern the abundant of natural concentration of certain component of groundwater (Maric et al., 2014) Competition for economic expansion resulted in rapid population growth, urbanization, industrialization as well as agricultural activities these trends lead to significant demand for water and therefore, needs for quality water increases (Mallick *et al.*, 2018). More than one sixth of the people living worldwide do not have access to clean water according to world statistic. Indian found to have the highest number of 76 million without clean water followed by China 63 million, Nigeria 58 million and Ethiopia with 43 million among others (Benneyworth *et al.*, 2016). The fundamental of study of groundwater is the geology of the environment because it controls both the groundwater quality as well as quantity. The nature and the properties of underlying rock formations chemical composition of aquifer yield and retention and groundwater are all products of the geology of the environment (McGrane, 2016).

Malaysia is a tropical country that have a lot of precipitation consistently, yet some time there is inadequate surface water supplies for domestic needs due to prolonged drought. On the other hand for fresh water supply coming from groundwater which is defined as subsurface water and can be either confined aquifer or unconfined aquifer which can be distinguished by its components (Abd-Elhamid and Javadi, 2011).

Groundwater in Malaysia has estimated storage capacity of 5000 billion cubic meters with an annual recharge of 64 - 120 billion cubic meters (Manap et al., 2013). It is widely distributed all over the country and can be found in aquifer namely alluvial, limestone, crystalline igneous rock and volcanic & sedimentary rocks (Umar Kura et al., 2013). The availability of clean water for agricultural purposes is threatened in most part of the world (Reyes et al., 2017; Pazand et al. 2018). A shortage of water supply becomes a serious challenge for agricultural activities and that will translate in food crisis due to increasing world population. Groundwater was known to be clean and free from pollution, but due to the rapid growth of population, industrialization, urbanization and increase use of chemicals numerous contaminants often find their way into the ground (Alberti et al; 2019). Groundwater contains pollutant that exceed the toxic limit these pollutant includes heavy metals, major ions and anthropogenic activities (Mallick et al., 2018). The biggest sources of industrial water pollution in Malaysia are food and beverage industries, chemical based industries, textiles, paper, palm oil and rubber processing industries such rapid development of industries however has increased the water pollution level in Malaysia (Mohammadi et al., 2010). Langat River is one of the most important raw water resources for drinking water, recreation, industry, fishery and agriculture in Selangor, Malaysia. The river flows from the highest peak of 1493 meter of Gunung Nuang across Langat Basin to Kuala Langat and land use activities along the river banks contribute to deterioration of river water quality. The sources of the Langat River pollution are identified as industrial discharge (58%), domestic sewage from treatment plants (28%), construction projects (12%) and pig farming (2%) (Samuding et al., 2018). All these pollutant are seeps into the groundwater which will constitute major contaminants. Groundwater contains a wide variety of dissolved inorganic constituent as a result of chemical interaction with geological material and to a lesser extend contribute from the atmosphere. Groundwater facing a lot of challenges from different factors that contaminate the fresh water underneath such as seawater intrusion, leaching processes of underlying rock mediated by pH, minerals weathering processes, and dissolution of carbonate minerals processes which is dominated by anthropogenic impact from over abstraction of freshwater from the aquifer (Noorabadi et al., 2017and Abd-Elhamid et al., 2011), that could be as a result of human activities or naturally.

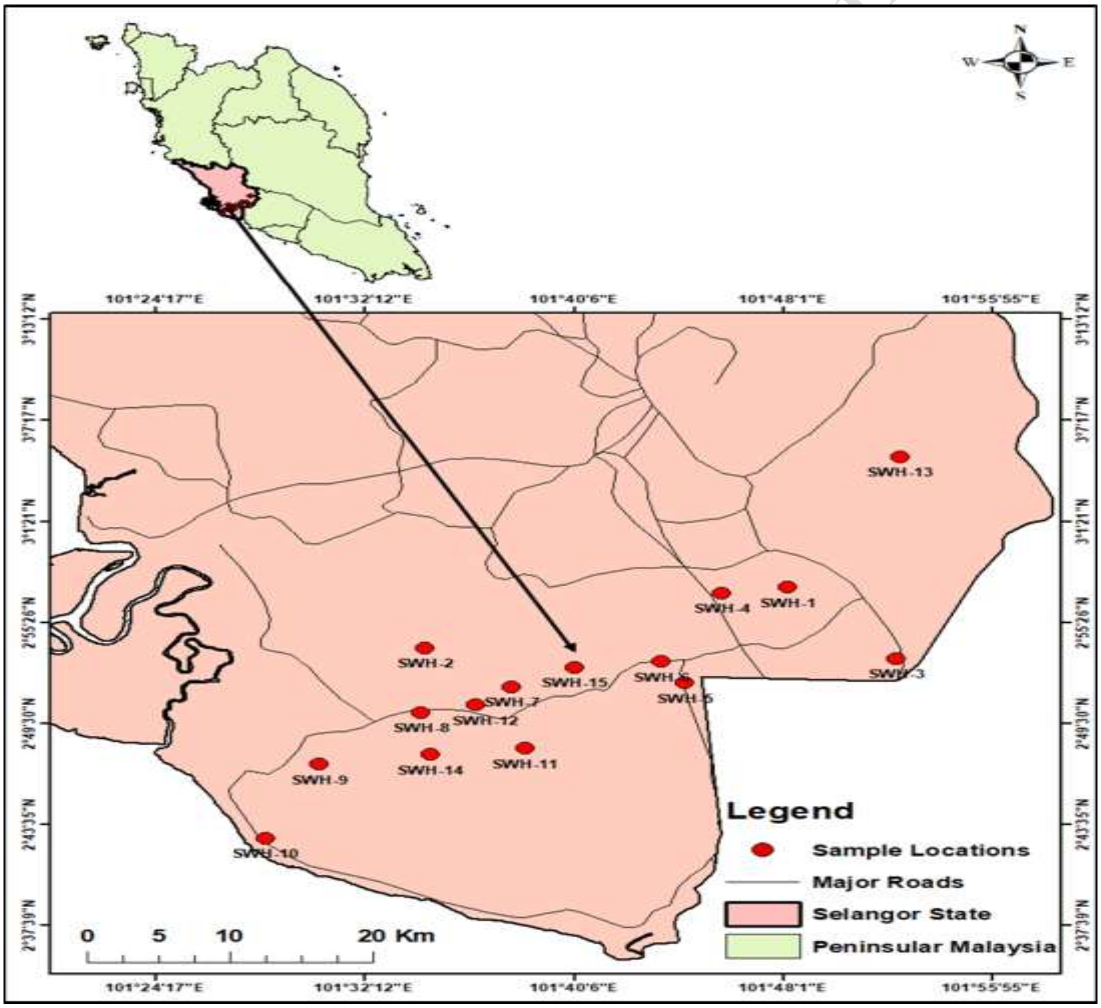
The objectives of this study are: to 1) determine groundwater hydrochemical characteristics, 2) identify the pollution sources, 3) to assess the suitability of groundwater for irrigation purposes. The output from this study will provide information on the suitability for irrigation activities which will contribute to the development of information to support decision making in taking appropriate measures in protecting and managing the groundwater resources in Langat river basin.

MATERIAL AND METHODS

2.1 Study area, Geology, Topography, Climate and Rainfall

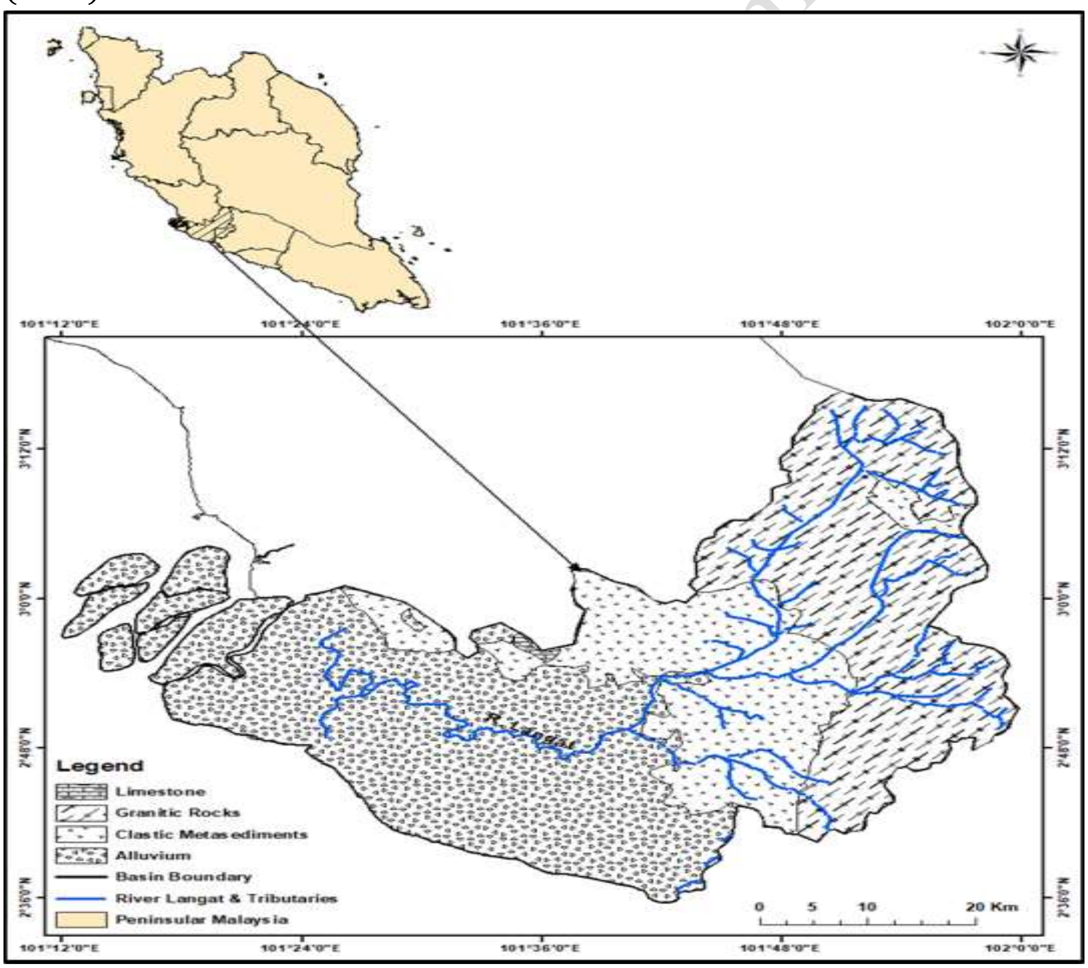
Study area is located within the Langat river basin in Selangor Malaysia covering an area of 2350km^2 that comprises the following districts Kuala Langat, Hulu Langat, and Sepang (.figure 1) The latitude and Longitude is (2° 53′ 32″ N and 101° 41′ 120.3″ E) respectively. The population of the three (3) districts is 1.4 million (Economic planning projection 2000). Hulu Langat is the largest district in Selangor and the population is estimated around one million in 2015. However the population of the (3) districts is on the increase annually due to urbanization, agricultural and industrialization.

Figure 1: Map of the study area with sample locations



The geology of the Langat river basin can be divided into 3 zones namely (Mahzan et al., 2017) mountainous, hilly and flat alluvial lowland. The sediments changes it composition gradually from big boulders in the mountainous zone to sand and silty in the hilly area lastly the alluvial lowland which characterize by peat with clay and silt soil. The mountain of peninsular is generally form by granite and it extend dawn to hilly area toward Cheras called Kenny hill formation. These formations consisting of transformation from sandstone, shale, mudstone and schist. The granite part is weathered (Polya et al., 2005). The flat alluvial lowland has the thick quaternary layers deposited on the bedrock. However there are four geological formation within the basin Simpang, Kempadang, Gula and Beruas formations. Groundwater recharging areas are in the upstream mountains and hilly areas then the aquifers are distributed in the flat alluvial lowlands. Figure 2 shows the geological formation of Langat river basin.

Figure 2: Geological map of Langat river basin, Adopted from Marker et al., (2011)



The temperature ranges from 21 to 32°C depending on the time the average is 26°C. There is abundant rainfall in Malaysia generally especially between October to March and the average annual rainfall is 2000 to 4000mm while the month of June to September usually considered as dry season with low rainfall (Althuwaynee et al., 2012). The study area is dominated with agricultural activities follows by residential (Table 1).

Table 1 Sampling Station, area, local authority and land Used

Sample Station	Area	Local Authority	Land Use
SWH 1	Pusat Jagaan Yatim-Alfrid	Kajang, Hulu Langat	Residential
SWH 2	Kampong Bukit Cheding	Kuala Langat	Agricultural
SWH 3	Klinik Kesihatan	Beranang, Hulu Langat	Residential
SWH 4	Pencawang Elektrik	Bangi,	Residential
SWH 5	Jenderam Hulu	Sepang	Agricultural
SWH 6	Kampong Orang Asli	Dengkil	Agricultural
SWH 7	Paya Endah Wetland	Dengkil	Agricultural
SWH 8	Bukit Mahkota	Banting	Residential
SWH 9	National Space Station	Banting	Agricultural
SWH 10	Kampong Indah	Ampang Jaya Hulu Langat	Agricultural
SWH 11	Pondok bastunal arafin	Klang	Agricultural
SWH 12	Tangkit Olak Lempit Air Selangor	Hulu Selangor	Residential
SWH 13	Pasir Batu kampung	Hulu Langat	Industrial
SWH 14	Maahad Kg Sg Kelumbu	Banting	Agricultural
SWH 15	Masjid Kg Dato Ahmad Razali	Dengkil	Residential

Groundwater sampling and Data analysis

Forty five (45) groundwater sample was collected in fifteen (15) different groundwater wells (SWH) on the 9th January to 14th January 2019.

Figure 2.The study area map and sampling points

GPS will be taking and all the coordinate to be recorded latitude, longitude and elevation. Groundwater water level were measured, then pumping of the groundwater for 15-20 minutes in order to remove stagnant water to avoid taking sample with contaminated groundwater. All probe need to calibrate before and after use in the field to have degree of accuracy of the sample taken for *In-situ* measurement are correct. Before going to the site all the apparatus for the purpose of the sampling need to be wash with detergent then rinsed them with distilled water. Dry all apparatus at room temperature. Soak the apparatus by applying acid wash technique with 5% nitric acid for overnight and rinse with distilled water. Dry all the apparatus in oven with room temperature of 60^{o}C for overnight and label each of the bottles specifically. *In-situ* parameters of pH, temperature (°C), salinity, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO) and turbidity were measured using multi probe. All cations, groundwater samples were filtered with 0.45μm filter except for anions. For cations, the samples were preserved with concentrated nitric acid after filtration. Groundwater samples were kept at 4ºC. Anions of bicarbonate and chloride (HCO_3^- Cl^-) were analysed by titration method based on APHA 2005. While sulphate and nitrate (SO_4^{3-} NO_3) were measured using Spectrophotometer DR2800 by adding reagent powder pillow. Cations calcium .magnesium, sodium and potassium. ($Ca^{2+,}$ $Mg^{2+,}$ Na^+, and K^+) were analysed with Atomic Absorption Spectrophotometry (AAS). Statistical Analysis were carried out for all the parameters using (SPSS) version 25. Test for correlation, descriptive statistic and compare means was conducted to determine the relationship of the parameters. Piper diagram was analysed to show the water type of the groundwater in Langat Basin as shown in the study design. (Figure3).

Groundwater Suitability for Irrigation Purpose

Groundwater for irrigation purpose generally rely on mineral constituent of water. there is effects on soil and plants (Chidambaram *et al.*, 2011) and (Wilcox, 1955)

Different methods can be used to determine the quality of groundwater for irrigation use. Total dissolved solids (TDS), is to describe the content of salt in the irrigation water. Sodium percent (Na %), Sodium adsorption ratio (SAR), Kelley index and Magnesium Hazards. (MH) were calculated using the standard formulas

(Equations 1-4).

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}} \qquad (1)$$

Example: 1 SWH1 = SAR $= \frac{463.92}{\sqrt{\frac{119.24+118.00}{2}}} = \frac{463.92}{\sqrt{\frac{237.25 \;\; =118.625 = 10.89}{2}}} \quad \frac{463.92}{10.89} \quad = 42.60$

Example 2 SWH2 $= \text{SAR} = \dfrac{252.57}{\sqrt{\dfrac{40.00+49.00}{2}}} = \dfrac{252.57}{6.67} = 37.86$

$$Na\% = \frac{Na^{+}+K^{+}}{Na^{+}+K^{+}+Ca^{2+}+Mg^{2+}} \times 100 \qquad (2)$$

Na% Example SWH1 $= \text{Na\%} = \dfrac{463.92+477.63}{463.92+477.63+119.24+118.00} \times 100 = 80.2$

$$\text{KI} = \frac{\text{Na}^{+}}{\text{Ca}^{2+}+\text{Mg}^{2+}} \qquad (3)$$

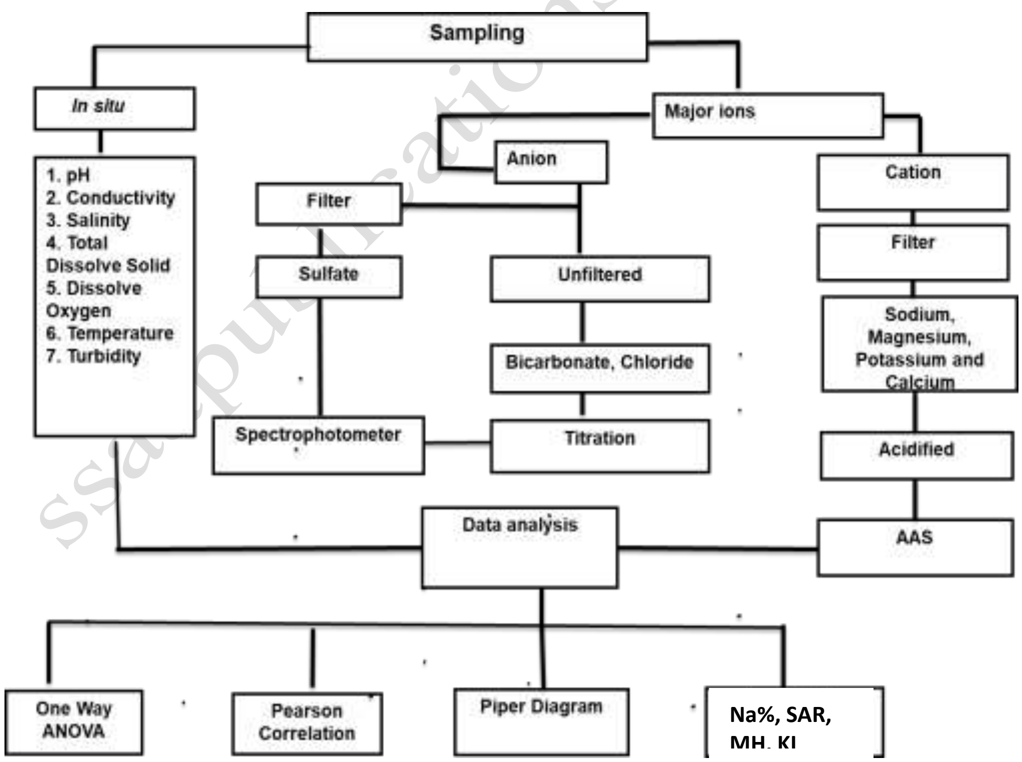
SWH1 KI $== \dfrac{477.63}{273.25} = 1.74$

$$MH = \frac{Mg}{(Ca+Mg)} \times 100 \qquad (4)$$

Example:

SWHI MH $= \dfrac{118.00}{273.25} \times 100 == 43.18$

Figure 3 Study Design



RESULTS AND DISCUSSION

General Chemistry

The groundwater in the study area is mostly acidic to neutral, as the pH value ranges from 4.48-7.58 with mean value of 5.98.which is slightly below the standard limit set by (WHO 2004). The low pH value might be due to the reaction of water and carbon dioxide that eventually produce hydrogen ions that lower the pH of groundwater water (Isa et al., 2015). Electrical conductivity (EC) ranges from 55-2818 µS/cm with an average of 603µS/cm most samples in the study area are within the permissibility set by (WHO), with only SWH2 sample higher above the standard limit and that could be as a result of geothermal evolution of groundwater through rock-water interaction (Iqbal et al., 2018). The concentrations of the parameter of the wells are ranges from station to stations.(Table 2)

Table 2: Row data of physicochemical parameters.

Station	pH	Temp (°C)	Salinity (ppt)	EC µS/cm	DO (mg/L)	TDS (mg/L)	Turbidity (NTU)
SWH 1	5.98	28.50	0.06	135	2.60	80	1.32
SWH 1	5.93	28.48	0.06	136	2.64	79	1.15
SWH 1	5.92	28.46	0.06	137	2.67	81	0.98
SWH2	5.90	29.14	1.34	2816	3.74	1698	9.99
SWH 2	6.05	29.20	1.34	2816	3.76	1704	9.99
SWH 2	6.02	29.23	1.34	2820	3.75	1695	9.99
SWH 3	6.59	29.43	0.16	379	3.06	227	2.49
SWH 3	6.64	29.45	0.16	379	3.05	227	2.49
SWH 3	6.86	29.86	0.17	374	2.96	228	2.36
SWH 4	6.02	28.79	0.05	109	2.48	66	9.99
SWH 4	5.95	28.79	0.05	109	2.50	66	9.99
SWH 4	5.95	28.78	0.05	109	2.49	66	9.99
SWH 5	5.22	30.24	0.02	56	2.18	33	9.99
SWH 5	5.18	30.19	0.02	55	2.18	33	9.99
SWH 5	5.17	30.18	0.02	56	2.18	33	9.99
SWH 6	5.85	28.41	0.10	22	2.90	136	1.71
SWH 6	5.82	28.79	0.10	22	2.65	136	1.89
SWH 6	5.93	28.93	0.10	22	2.68	136	1.74

SWH 7	5.51	30.50	0.13	310	2.50	180	9.99
SWH 7	5.45	30.45	0.13	305	2.46	180	9.99
WSH 7	5.49	30.44	0.13	306	2.46	180	9.99
SWH 8	6.49	29.40	0.40	80	3.10	35	0.88
SWH 8	6.39	29.39	0.40	80	3.50	35	1.00
SWH 8	6.66	29.70	0.40	80	3.40	35	0.78
SWH 9	7.05	31.80	3.80	80	1.70	95	2.26
SWH 9	7.10	31.60	3.70	80	2.00	95	1.40
SWH 9	7.16	31.60	3.80	80	2.30	95	1.58
SWH 10	7.58	29.20	8.00	80	2.10	201	4.46
SHW 10	6.29	32.00	8.20	80	1.80	201	5.32
SWH 10	6.30	32.00	8.20	80	1.90	201	6.02
SWH 11	6.08	29.49	0.30	70	2.85	420	4.14
SWH 11	5.97	29.47	0.31	70	2.82	420	4.16
SWH 11	5.90	29.49	0.31	70	2.79	420	4.84
SHW 12	6.95	30.10	0.01	80	2.60	26	1.14
SWH 12	6.91	30.10	0.10	80	2.90	26	1.48
SWH 12	6.40	30.10	0.10	80	2.90	26	1.16
SWH 13	4.76	31.16	0.04	105	1.91	61	0.70
SWH 13	4.67	31.14	0.04	104	1.87	61	0.80
SWH 13	4.68	31.20	0.04	105	1.86	61	0.90
SWH 14	7.04	28.80	2.30	80	1.90	56	4.52
SWH 14	7.07	28.90	2.30	80	1.30	58	4.25
SWH 14	7.12	29.10	2.30	80	1.10	55	4.87
SWH 15	5.37	29.79	0.09	222	3.01	132	0.70
SWH 15	5.29	29.78	0.10	226	2.92	137	0.68
SWH 15	5.23	29.23	0.09	229	2.88	137	0.57

The concentration of cations is in this order $K^+ > Na^+ > Ca^{2+} > Mg^{2+}$. Potassium values in groundwater range from 2.91- 477.63 mg/L. Station SWH1, SWH2 and SWH3 is exceed the standard limit. Sodium ranges from 1.07 – 463.92 mg/l. Station SWH1, SWH2, SWH3 and SWH4 exceed the limit set by WHO. Calcium and Magnesium are common element in wate their concentration ranges from 9.82 - 119.2 mg/L and 0.62 -118.0 mg/L, respectively. Station SWH 1 and SWH2 are above the permissibility limit for drinking. Therefore 90% of the groundwater in the study area within the limit and is drinkable.shows in table and graph. The presence of Ca^{2+}ions in groundwater is drive from ion exchange of minerals from rock (October et al., 2013). Ca^{2+} can also be drive from $CaCO_3$ and $CaMg(CO_3)_2$. For Mg^{2+} concentration, it can be also from the ion exhange. The Potassium concentration has shows in station SWH1, SWH2, and SWH3 to be higher than the other stations this indicates that it may drive from effluent of industrial area as the station is situated in an urban centres and agricultural centres fertilizer application may contain the K^+which is most likely found in fertilizers which contribute to the K^+ concentration. In the case of Na^+ it has the domination of cations in the study area which is shows the source is from silicate weathering, sewage contamination and agricultural runoff infitration and the exchange of cations (Yang et al., 2018 and Sinha et al., 2017). The industrial effluent may have increases the Na^+ content for the fact the stations are located at the urban centers.

The major cations abundance in the different groundwater wells, is where the main composition of groundwater is highly affected by lithology of rocks in addition to human activities (Logeshkumaran et al., 2015). The Na^+ ion concentrations of cations exchange through water rock interaction in addition to human activities are the main reasons for the increase Na^+ level in groundwater. Generally the concentration of HCO_3^- comes from dissolution of carbonic acid and carbonate minerals (Abdel-Satar *et al.*, 2017). Station SWH10 recorded high concentration might come from the application of fertilizer which is near by palm plantation (Toriman et al., 2016). Cl^- ion that apply in the agricultural activities is not absorbed by the soil, therefore it transported and end up in the groundwater system. The dominance of anions Bicabonate,chloride,sulphatr and nitrate ($HCO_3^- > Cl^- > SO_4^{3-} > NO_3^-$) all parameters were shown in (Table 3). And (table 4) shows the statistical parameters

Table 3 Average data for all parameters for Langat river basin

Station	pH	T (^{0}C)	Sal (ppt)	EC (µS/cm)	DO (mg/l)	TDS (mg/l)	TBD (NTU)	HCO_3^- (mg/l)	Cl^- (mg/l)	NO_{3-} (mg/l)	SO_4^{2-} (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)
SWH 1	5.94	28.48	0.06	136	2.63	80.00	1.15	135.00	167.00	1.00	1.00	119.2	118.0	463.92	477.63
SWH 2	5.99	29.19	1.34	2818	3.75	1698.0	9.99	673.00	132.00	0.80	0.00	41.00	49.0	252.57	428.40
SWH 3	6.69	29.58	0.16	380	3.02	277.00	2.45	688.00	419.00	0.40	0.00	31.09	40.21	313.86	385.66

SWH 4	5.97	28.78	0.05	106	2.49	66.00	9.99	118.00	142.00	1.20	0.00	17.92	12.93	156.70	122.20
SWH 5	5.19	30.20	0.02	55	2.18	33.00	9.99	37.00	154.00	2.30	1.00	10.80	3.55	20.99	31.57
SWH 6	5.86	28.66	0.10	220	2.74	136.00	1.76	181.00	179.00	1.80	1.30	29.19	4.67	27.39	24.79
SWH 7	5.48	30.46	0.13	305	2.74	180.00	9.99	20.00	157.00	0.50	0.00	12.69	8.61	54.70	80.75
SWH 8	6.51	29.57	0.40	80	3.30	35.00	0.89	164.00	79.00	0.90	0.00	51.45	1.58	5.56	28.78
SWH 9	7.01	31.66	3.70	80	1.90	95.00	1.74	2493.0	2065.00	0.00	6.70	14.56	18.43	11.22	85.01
SWH 10	6.72	31.00	8.10	80	1.90	201.00	5.26	1178.0	4863.00	0.50	2.00	9.82	2.66	1.07	2.91
SWH 11	5.98	29.48	0.30	70	2.82	420.00	4.38	482.00	175.00	0.00	0.00	21.46	0.62	8.67	30.57
SWH 12	6.75	30.10	0.10	85	2.60	26.00	1.26	390.00	29.00	0.60	0.00	11.05	21.71	18.59	25.22
SWH 13	4.73	31.17	0.04	105	1.88	61.00	0.80	246.00	14.00	0.70	7.00	55.98	3.33	65.20	25.19
SWH 14	7.08	28.93	2.30	80	1.43	56.00	4.55	1476.0	10.00	0.30	1.50	16.09	14.74	13.51	51.66
SWH 15	5.29	29.76	0.93	225	2.93	135.00	0.65	59.00	14.00	1.70	27.00	110.8	55.95	276.00	129.70

Table 4: The Descriptive Statistics of physio-chemical characteristic and hydro geochemistry concentration (mg/l) of water quality of all the stations

	N	Minimum	Maximum	Mean	Std. Deviation	WHO
		0.09	7.58	5.85	1.44	
Temp (°C)	45	28.41	32.00	29.81	1.00	
Salinity (ppt)	45	0.02	8.20	1.13	2.16	
Cond (µs/cm)	45	55.00	2820.00	603.10	6681.41	
DO (mg/L)	45	1.70	3.76	2.62	0.54	
TDS (mg/L)	45	26.00	1704.00	229.82	409.61	
Turbidity (NTU)	45	0.57	9.99	4.32	3.73	
Bicarbonate (mg/L)	45	0.32	2586.00	0.60	0.72	
Chloride (mg/L)	45	0.70	4915.00	0.73	1.24	
Nitrate (mg/L)	45	0.00	4.40	0.98	0.96	

Sulphate (mg/L)	45	0.00	28.00	3.14	6.84
Calcium (mg/L)	45	8.66	204.60	40.94	46.70
Magnesium (mg/L)	45	0.17	1474.00	56.15	218.52
Sodium (mg/L)	45	0.42	480.07	112.00	145.18
Potassium (mg/L)	45	1.70	597.00	128.69	159.87

Correlation

Correlation was used to determine the relationship between the groundwater chemistry in order to assess the pollution for effective quality of groundwater management. TDS shows strong relationship with EC r=0.886 P=0.01 EC is the ability of water to conduct electricity while TDS is the measure of dissolved ions in the water. Therefore the variation of different minerals present in the water increases the ability of water to conduct electricity. So the higher the concentration of dissolved ions the more the conductivity increases. There is strong relationship between bicarbonate and chloride r = 0.738 which have been justify in piper diagram as there were some sampling stations that have mix water type of sodium bicarbonate chloride (Na-HCO3-Chloride) Positively relation of Ca^{2+} and Na^{+} is due to presence of chemical fertilizer (Devic and Serre, 2014). Generally cations have strong relationship with each other where Mg^{2+} and K^{+} shows strong relationship. The relationship of cations is due to exchange between Ca^{2+}or Mg^{2+} that increase the sodium concentration in groundwater (Guo et al., 2015). The increase in HCO_3^-in groundwater is as a results of decrease in groundwater pH which lead to the dissolution of insoluble carbonate. Previous study shows that there is strong relationship between the TDS and the cations like Sodium Potassium, Calcium and Magnesium. In this study it shows that there is no relationship between the TDS, EC and Salinity. But there is strong relationship between the EC and TDS.

Table 5 Correlation Analysis for Significant relationship

	pH	Temp	Sal	Cond	Do	TDS	Turbidity	HCO_3^-	CL^-	NO_3^-	SO_4^{-2}	Ca^{2+}	Mg^{2+}	Na^+	K^+
pH	1														
Temp	-0.043	1													
Salinity	0.324*	0.446**	1												

EC	0.254	-0.044	0.267	1											
DO	-0.041	-0.522**	-0.393**	0.536**	1										
TDS	0.026	-0.160	0.056	0.886**	0.580**	1									
Turbidity	0.066	-0.061	0.037	0.258	0.023	0.413**	1								
HCO_3^-	0.459**	0.457**	0.790**	0.232	-0.415**	-0.036	-0.103	1							
Cl^{-}	0.269	0.447**	.0991**	0.297*	-0.362*	0.117	0.068	0.738**	1						
NO_3^-	-0.340*	-0.317*	-0.298*	-0.225	0.098	-0.054	0.093	-0.458**	-0.253	1					
SO_4-	-0.724**	0.203	-0.031	-0.196	-0.057	-0.133	-.0375*	-0.040	-0.004	0.139	1				
Ca^{2+}	-0.371*	-0.341*	-0.276	-0.170	0.191	-0.031	-0.422**	-0.338*	-0.249	0.362*	0.376*	1			
Mg^{2+}	-0.161	-0.372*	-0.188	0.067	0.283	0.183	-0.212	-0.152	-0.148	0.254	0.204	0.851**	1		
Na^+	-0.261	-0.413**	-0.294	0.024	0.362*	0.255	-0.088	-0.298*	-0.244	0.278	0.213	0.770**	0.913**	1	
K^+	0.017	-0395**	-0.198	0.323*	0.470**	0.502**	0.056	-0.142	-0.159	0.116	-0.083	0.560**	0.811**	0.875**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Piper diagram shows that most of the sampling station has a mix of (Na^{+}, HCO_3^{-} Cl) and (Na^{+} Cl^{-}) of groundwater type. (Figure 4) the label D is sodium chloride (Na-Cl) groundwater type and C is sodium bicarbonate chloride (Na-HCO3-Cl) groundwater type. Most of the sampling station is dominated with sodium ions and potassium ions and is due to cation exchange between Calcium and Magnesium while anions of bicarbonate (HCO_3) and then Chloride (Cl^{-}) follows. Which indicate there is high mineral contains (Karuppannan *et al.*, 2018). While the mix of Na^{+} HCO_3^{-} Cl^{-} groundwater type is as a result of freshwater that mixed with salt water and it has the influence of urban, agriculture and industrial activities contribute to the salinization of the groundwater. Abdallah and Khalil (2018). Figure 4 is the illustration of the piper diagram.

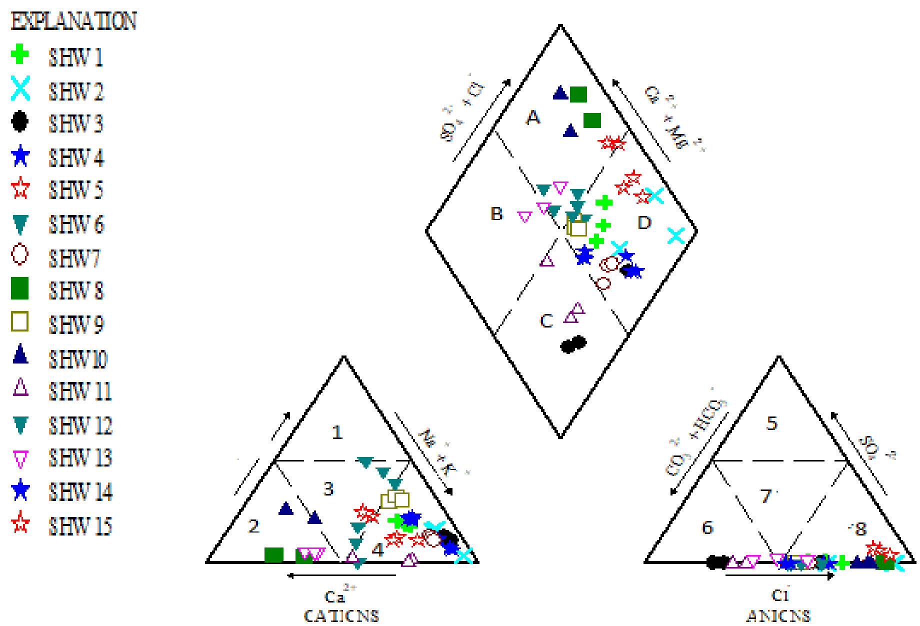


Figure 4 piper diagram to determine water type

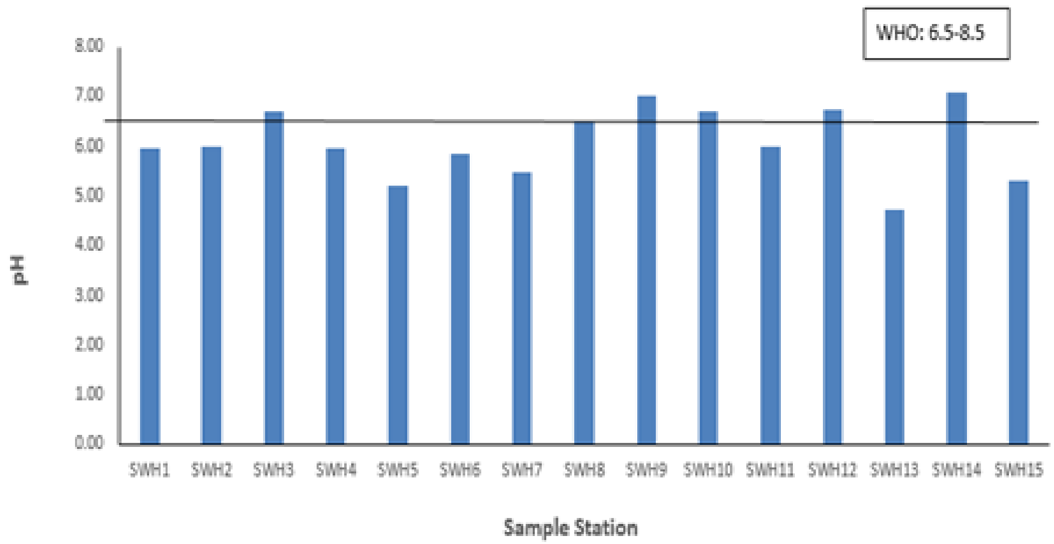
The Piper diagram can be separated in hydrochemical facies as shown in the legend.

A =calcium carbonate	1=Magnesium	5=No dominance
B =No dominance	2=calcium	6=bicarbonate
C =sodium bicarbonate chloride	3=potassium	7= No dominance
D =sodium chloride	4=sodium	8= chloride

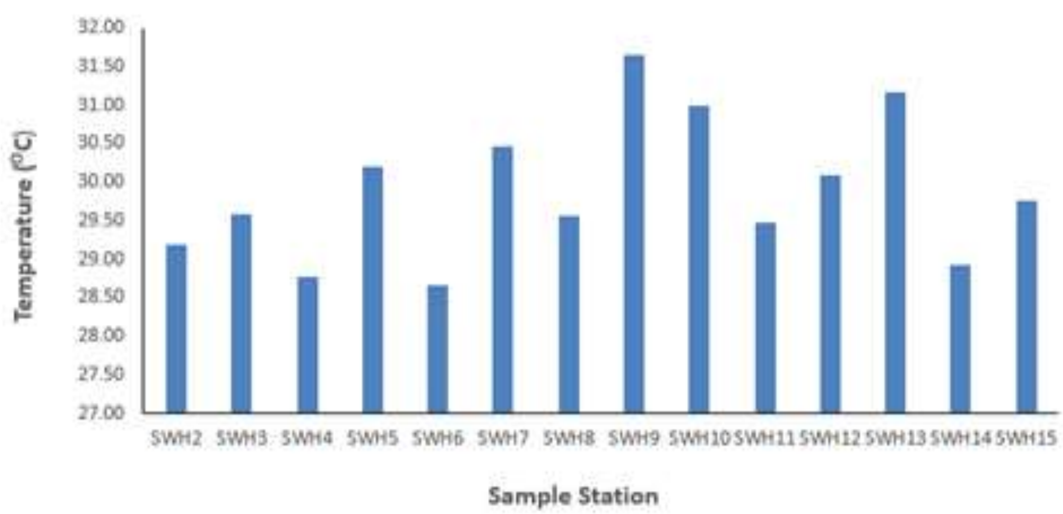
Figure 5, 6 and 7 shows all the graphical representation of the concentration of all the parameters. Figure 5 shows the concentration of all the *In-situ* parameters in bar graph. pH concentration of SWH 1.2,4,5,6,7,11,13 and 15 is lower than the standard limit WHO 2004.These might be as a result of reaction of water with carbon dioxide that eventually produce hydrogen ions (Isa *et al.*, 2014) SWH 3,8,9,10,12 and 14 are within the permissible limit. Electrical conductivity (EC) and TDS concentration of SWH 2 exceed the permissible limit and that might be because of proximity to the sea. Groundwater with this concentration will cause a disease call gastrointestinal irritation (Mukate *et al.*, 2017).

Figures 5(a,b,c,d,e,f and ,g) pH,Tempereture,Salinity, Dissolved oxygen,EC,TDS,and Turbidity

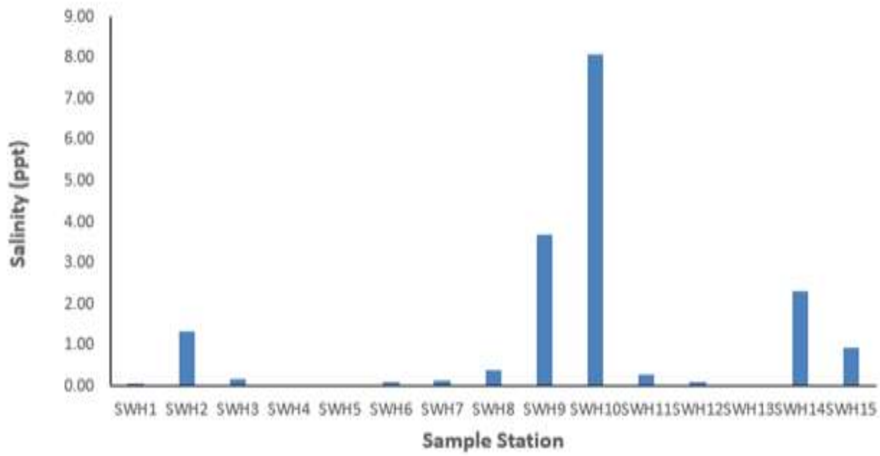
(a)PH



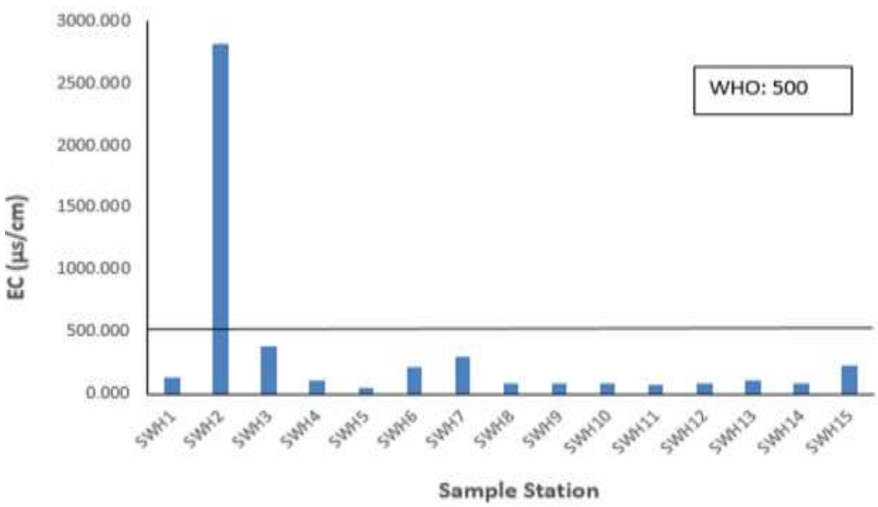
(b) Temperature



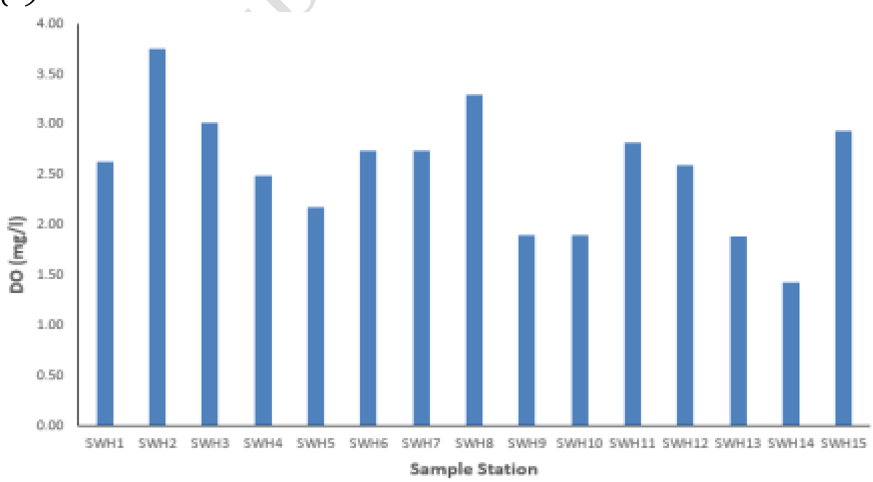
(c) Salinity


Salinity (ppt)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
SWH1 SWH2 SWH3 SWH4 SWH5 SWH6 SWH7 SWH8 SWH9 SWH10 SWH11 SWH12 SWH13 SWH14 SWH15
Sample Station

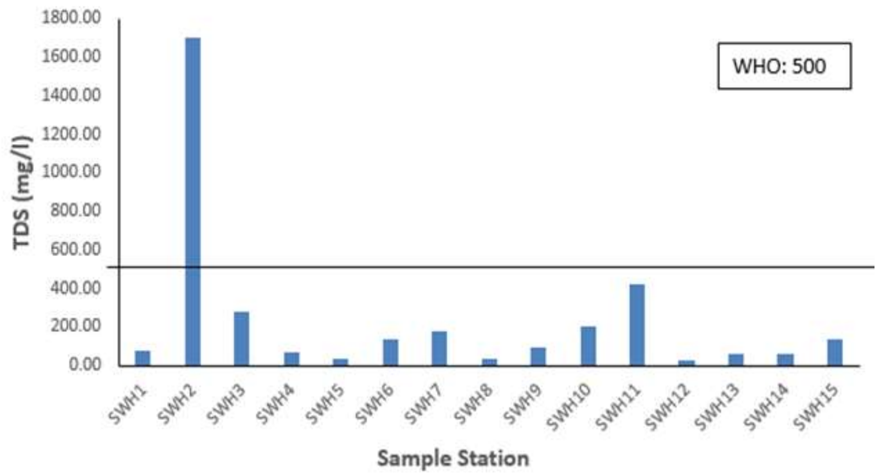
(d) EC


EC (µs/cm)
3000.000
2500.000
2000.000
1500.000
1000.000
500.000
0.000
WHO: 500
SWH1 SWH2 SWH3 SWH4 SWH5 SWH6 SWH7 SWH8 SWH9 SWH10 SWH11 SWH12 SWH13 SWH14 SWH15
Sample Station

(e) DO


DO (mg/l)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
SWH1 SWH2 SWH3 SWH4 SWH5 SWH6 SWH7 SWH8 SWH9 SWH10 SWH11 SWH12 SWH13 SWH14 SWH15
Sample Station

(f) TDS



(g) Turbidity

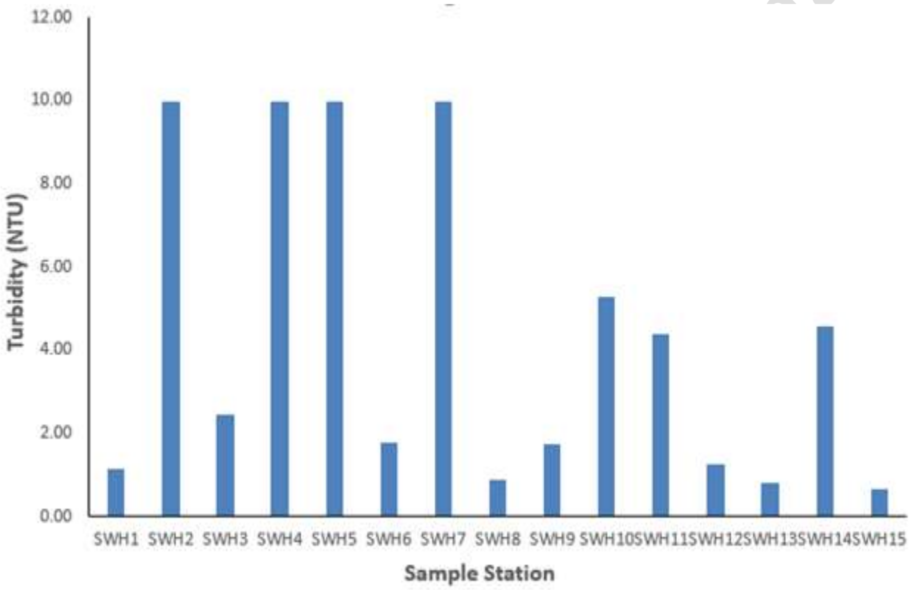
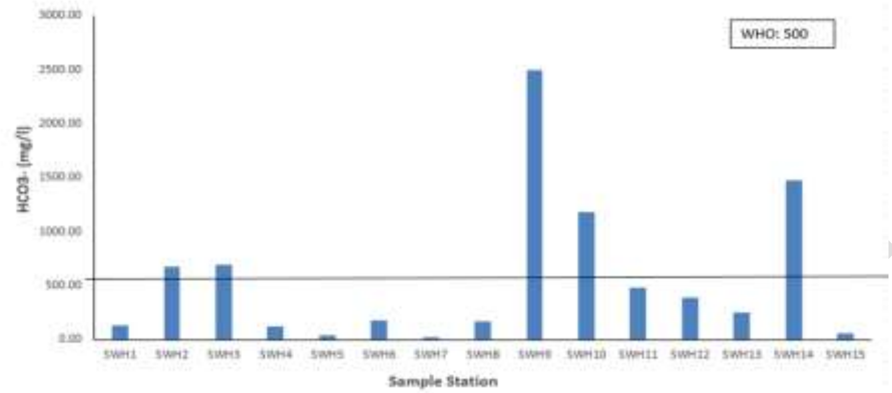


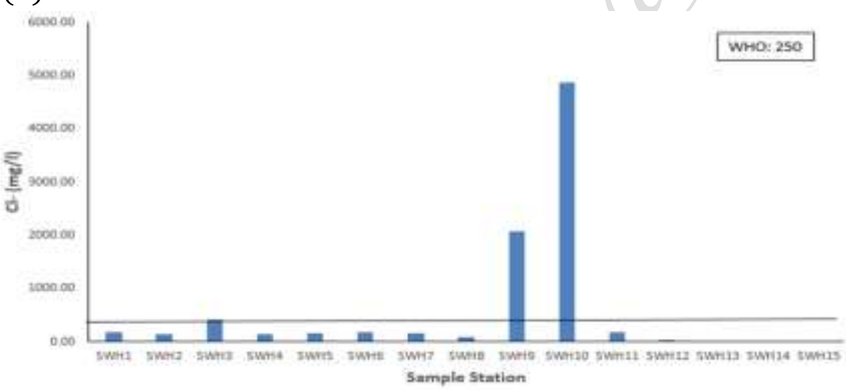
Figure 6 shows the concentration of anions for all stations in bar graph form. for bicarbonate Stations SWH 2, 3,9,10 and 14 exceed the permissible value (WHO 2004)(.figure 6) These high concentration might be as a result of dissolution of carbonic acid and carbonate minerals (Isa et al., 2014). While the other Stations are within the permissible value. For Cl- concentration SWH 3, 9 and 10 exceed the limit and the high concentration is associated with fertilizer application because all Stations SWH 9 and 10 are located in agricultural areas. SWH 9 and 10 has a very high concentration of chloride 2065 mg/l and 4863 mg/L respectively. The high concentration of these stations are as a result of proximity with agricultural activities where fertilizers and pesticide and also pollution from human sewage and animal manure were been used. Sulphate and nitrate are all below the permissible limit with Station SWH 15 only has the concentration of 27 mg/L and this might be the location is close to agricultural area.

Figures 6 (a, b, c and d) Bicarbonate, Chloride, Nitrate and Sulphate

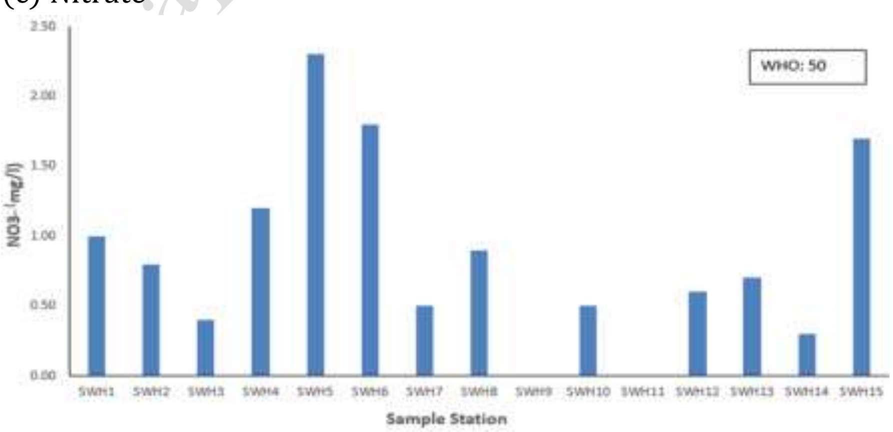
(a) Bicarbonate



(b) Chloride



(c) Nitrate



(d) Sulphate

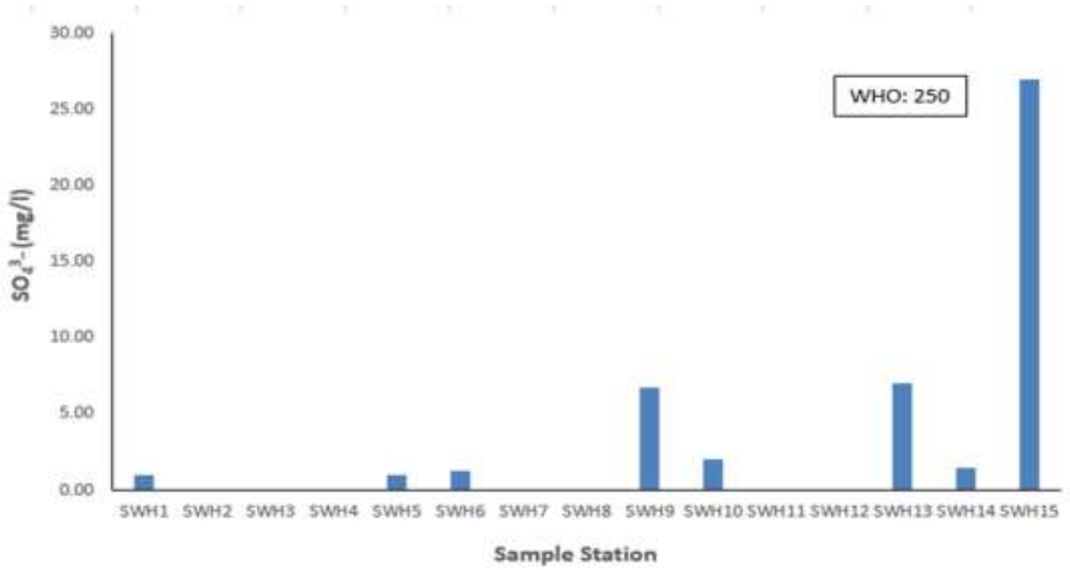
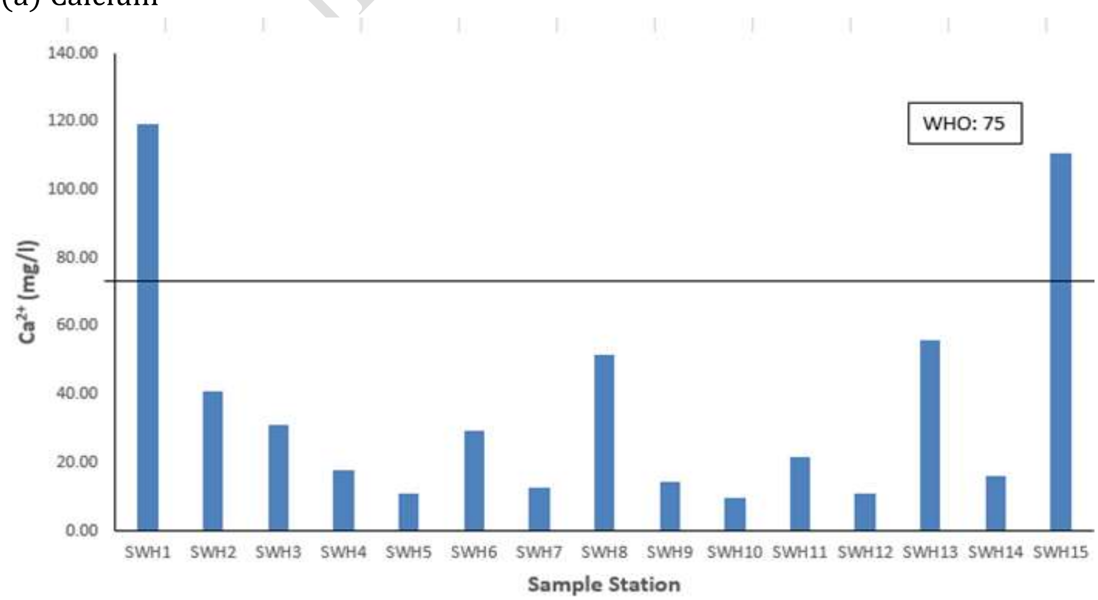


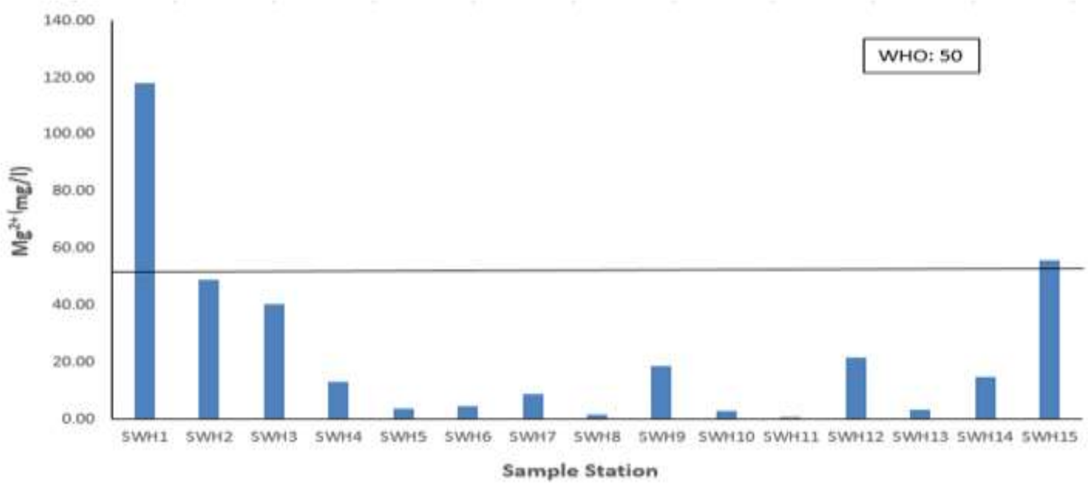
Figure 7 shows that the concentration of cations for all stations is represented in bar graph. Stations SWH 1 and 15 concentration of Ca^{2+} has exceeded the permissible limit. The presence concentration of $Ca2^{+}$ ions are coming from ion exchange of mineral from rock. Malaysia is mainly composed of CaCO3 type of rock spread all over the study area.

Figure: 7 (a, b, c and d) Calcium, Magnesium, Sodium and Potassium

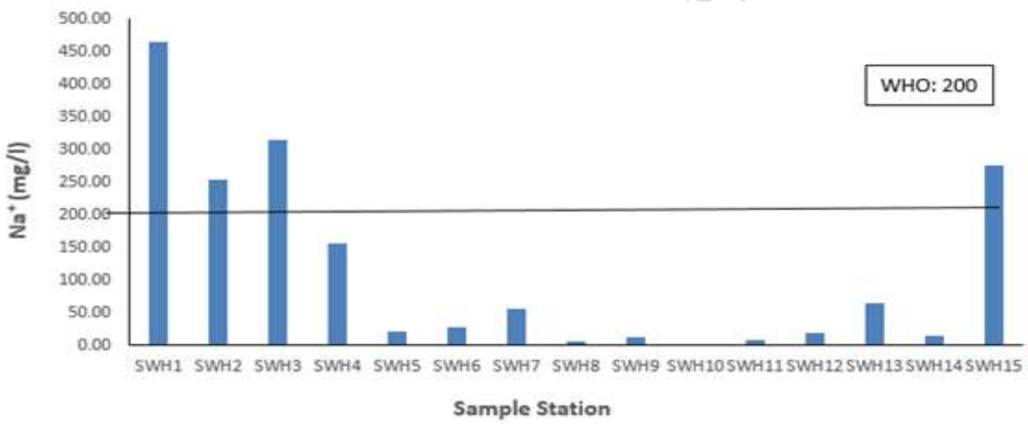
(a) Calcium



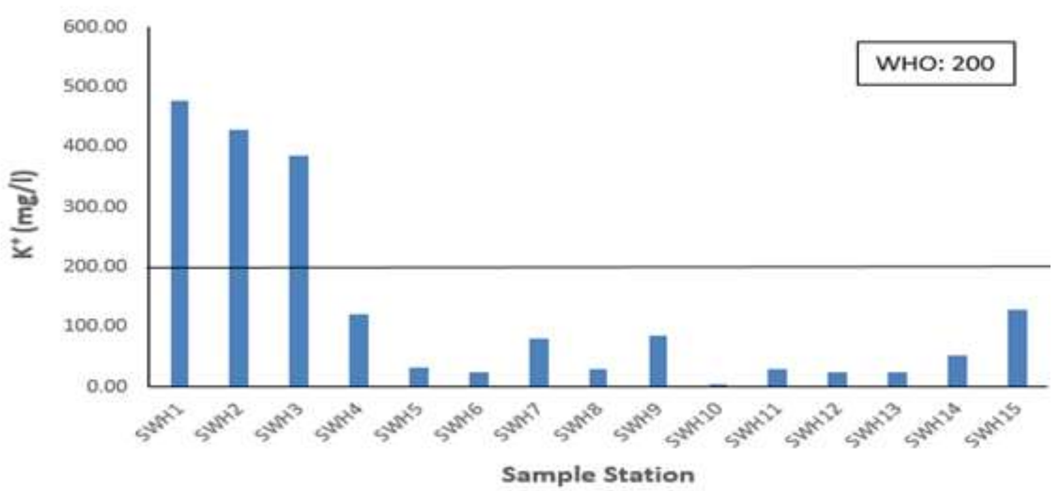
(b) Magnesium



(c) Sodium



(d) Potassium



Equation 1 give an idea about the level of replacement of sodium with other ions present in the soil which results in sodium hazard. Table 7 shows 65 % of the wells are in a class of excellent, good and permissibility respectively for irrigation use Table 6 shows the results of calculated equation of all the parameters.

Table 6: The results of the concentration of the Na %, SAR, MH and KI Ratio and EC

Sample Station	Na %	SAR	KI Ratio	MH	EC
SWH1	85.00	42.00	1.95	49.00	136
SWH2	87.00	23.00	2.80	54.00	2818
SWH3	87.00	28.00	4.40	56.00	380
SWH4	74.00	14.00	5.07	41.00	106
SWH5	34.00	1.98	1.46	24.00	55
SWH6	34.00	2.49	0.80	13.00	220
SWH7	58.00	4.98	2.50	40.00	305
SWH8	26.00	0.50	0.10	2.90	80
SWH9	49.00	1.02	0.34	55.00	80
SWH10	3.90	0.09	0.08	21.00	80
SWH11	28.00	0.70	0.39	2.80	70
SWH12	31.10	1.69	0.56	66.00	85
SWH13	50.00	5.93	1.09	5.60	105
SWH14	40.20	1.23	0.43	47.00	80
SWH15	79.90	25.00	1.65	33.00	225

Water with very high salt concentration is risky and harmful to the crop because it causes osmotic pressure in soil solution (Thorne and Peterson, 1954) Therefore). The permeability of soil can be decreased through ion exchange process. Whenever there is reaction of Na^+ and soil. It is advisable for farmers to use guidelines to have an idea if the quality of available water is suitable for usage. Eaton (1950) point out that if the concentration of CO_3 and HCO_3^- in groundwater is more than that of $Ca^{2+}$and Mg^{2+}ions concentration it is harmful to agriculture (irrigation).Kelley ratio equation said when ratio is less than 1 is safe for irrigation that is suitable. But in a situation the ratio is above 1 is unhealthy to use for irrigation which indicate too much amount of sodium in the water. Table 7 shows that the study area has 70 % of the sample wells are safe to use for irrigation.

Table: 7 Classification of groundwater for irrigation use

Parameters	Range	Water Class	Sample station
Na%	Less than 20	Excellent	2
	20-40	Good	4
	40-60	Permissible	4
	60-80	Doubtful	2
	Greater than 80	Unsuitable	3
S A R	Less than 10	Excellent	10
	10-18	Good	1
	18-26	Doubtful	2
	Greater than 26	Unsuitable	2
E C	Less than 250	Excellent	12
	250-750	Good	2
	750-2000	Permissible	0
	2000-3000	Doubtful	1
	Greater than 3000	Unsuitable	0
Magnesium Hazard	Less than 50	Safe	11
	Greater than 50	Unsafe	4
Kelly's Ratio	Less than 1	Safe	7
	Greater than 1	Unsafe	8

In the case of Magnesium Hazard which has point out by (Raghunath, 1987) Mg^{2+} that exceed the value of 50 in the water suggest it is risky and harmful because it affects the crop yield as the soil become more alkaline (Lakshmanan, Kannan and Kumar, 2003).

CONCLUSION

Groundwater quality contamination, source of pollution and suitability for irrigation purpose has been assess in the study area. The pH value generally of acidic with an average value of 5.98 slightly below the standard limit. The total dissolved solid (TDS) and electrical conductivity (EC) in the study area are 95%

permissible for drinking with only SWH2 exceed the limit with 1698 mg/L and 2818 mg/L respectively.

Major ions distribution in the groundwater ($Na^+ > K^+ > Ca^{2+} > Mg^{2+}$). For cations and ($HCO_3^- > Cl^- > SO_4^{3-} > NO_3^-$.) For anions.

The groundwater type is (Na^+ Cl^-) which dominate $Ca^{2+}$and Ma^{2+} as a result of the dominancy it removes the unit of Ca^{2+} and Mg^{2+} that are responsible for hardness.

SO_4^{3-} and NO_3^- concentration below the permissible limit. Which shows less influence from agricultural activities.

75% of the wells are suitable for irrigation purpose which was examined through Na%, sodium adsorption ratio (SAR), Electrical conductivity (EC), Kelley's index and Magnesium Hazards (MH). The result shows that while some few wells are slightly above the limit and very few are not suitable for usage. Therefore Periodic monitoring of the study area good in order to assess the activities that can lead to a threat to the groundwater quality to prevent deterioration of the wells for safe drinking water and irrigation use.

Acknowledgments

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Highlights

- Identifying hydro geochemical processes in order to determine groundwater status
- Groundwater quality is suitable for irrigation use.

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