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Groundwater Hydro Chemical Characteristics and Water Quality Assessment

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Abstract – This research aims at determining the quality of the groundwater in Manavalakurich. A total of 30 soil water samples from open wells and boore wells will be collected randomly for this research. In the laboratory, conventional methods were used to evaluate the concentration of main ions and other geochemical characteristics in groundwater. The order of the main cations was observed in the research region Na+ > Ca2+ > Mg2+ > K+, whereas the sequence of dominant anions was Cl−>HCO−3>SO2−4Cl−>HCO3−>SO42. In a piper trilinear diagram, hydro geochemical faces of the groundwater samples were examined to demonstrate saltwater intrusion in the research area. The geochemical parameters collected were compared with the acceptable limits proposed for determining the quality of drinking water in the region under investigation by the World Health Organization and the Indian Standard Institution. The study revealed that the soil water from the W25 and W26 wells is not appropriate for drinking. Soil water appropriateness has been assessed using sodium, sodium and residual sodium carbonate calculations percentage. The plots of Wilcox and USSL have been developed. The water from stations W1, W25 and W26 has been determined to be inadequate to irrigate. The Gibbs plots have also been designed to investigate the geochemical composition control mechanism of groundwater in the research region.

Keywords – Groundwater, Hydro Chemical, Characteristics, Water Quality, Assessment, etc.

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INTRODUCTION

Groundwater is the world's most extensive source of fresh water. It provides water for household use, apart from other uses, in many areas of the globe, is a key source of renewable energy. Groundwater abstraction has grown for agricultural purposes owing to the unusable supply of surface water causing recurrent monsoon failures. This has led to enormous strain on groundwater resources and also to water quality deterioration. Groundwater always includes dissolved ions. Due to different geochemical and biological processes that occur on the soil-ground water-rock system, the concentration of these ions varies throughout the course of the flow. In addition the ion level is added in soil waters by the natural processes like weathering of minerals, ion exchange, interactions with rock water etc. and human intervention by agricultural activity. The hydrochemical processes in aquifers should be identified and understood and the distribution of key ion chemicals in groundwater in a region should be assessed. Chemical properties of natural water where the potential origins in different forms of main ions and soil water quality were discussed. An important problem in heavily irrigated areas is the evaluation of effects of agricultural operations on groundwater systems. The widespread use of inorganic fertilisers as a basis for high yields and numerous effects on soil and groundwater is rooted on modern agriculture activity.

PHYSICAL PARAMETERS OF GROUNDWATER

On the field at the time of sampling, the most frequent physical parameters were EC, pH, Eh offers valuable basic information about the region. The groundwater is colourless, odourless and has a different flavour depending on the region. The average value is 6.9 and ranges from 6.5 to 8.3. PH water is a very essential quality indicator that is regulated by the quantity of carbon dioxide, charcoal and bicarbonates that are dissolved. Salts may be added to the water and pH can increase rapidly. The CaCo3 raises the alkaline pH of water. Ms Ghandour et al (1985) With increased salinity, pH falls. In this region the pH values of the soil water samples are within the allowable range (BIS, 2003). There is a rather high pH in the centre region. The groundwater is generally alkaline. The

EC of the soil of the studied area 625 to 4688 µS/cm, with the mean value of 1958 µS/cm.

MAJOR ION CHEMISTRY

The analysis of the main groundwater concentration in the region will give information on an aquifer's hydro chemical condition. The dissolved main cation and anion concentrations in the groundwater are regional and seasonal. The general order of dominance of cations is $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and for anions is $HCO_3^- > Cl^- > SO_4^{2-} > CO_3^-$. Thus Na^+ and HCO_3^- are the dominant ions present in groundwater.

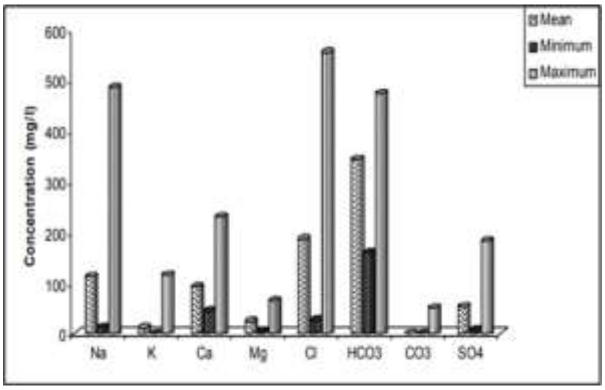

Figure 1: Range of concentration of major

SPATIAL VARIATION OF MAJOR IONS

The main groundwater concentrations in the studied region fluctuate geographically by groundwater recharge, because of variations in precipitation volumes, irrigation returnees, agricultural activities, and the formation's geochemical responses. Among the alkalis, sodium is a major natural water chemical component. The predominant cation in the studied region is sodium ion, ranging between 10 and 457 mg/l. In the northwest and south of the research region, the maximum sodium ion concentration is observed. The size of potassium ranges between 1 and 159 mg/l and changes seasonally. The presence of potassium is less in nature and thus less than sodium is discovered. In well nos 16 and 29, maximum potassium content is found. The weathering of silicates may lead to a high salt content and a comparatively low potassium concentration in groundwater. Few studies have documented this kind of low potassium and high salt content (Mohan et al 2000).

HDROCHEMICAL FACIES OF GROUNDWATER

By placing the concentration of main cations and anions in piper trilinear diagram, the geochemical character of the underwater may be understood. In Piper's trilinear diagram (1953) a chemical relation in groundwater is very helpful. This is helpful for understanding the overall chemical character of cations and anions in groundwater samples. The most dominating region of the research is sodium and bicarbonate is the most prevalent anions. From the piper diagram, the main ion chemistry of the groundwater has been identified four key hydro chemical faces. They are the following:

- $CaHCO_3$ Type
- NaCl Type
- Mixed CaMgCl Type
- Mixed $CaNaHCO_3$ Type

HDROCHEMISTRY AND LAND USE

The majority of the region under investigation is cultivated intensively, human habitation and the other portion is isolated hills and woods, especially in the northern section of the field. Therefore, the variability in land use in this region as elsewhere is reflected in the hydrochemistry. Variation in the quality of the groundwater in one zone depends on the physical and chemical components of which geological formations and human activities are significantly affected. The geographical change between land use and hydrochemistry was found at many locations. As the soil is deep-red and agricultural and mainly dry plant cultivation and also quite near to the forest region is not a human habitation, it is likewise deeply red. The wells near to the human population, the salty soil and intensive farming are very salty. In certain puits in the saline nature, the aquifer itself is the result of geological development and soil nature is most salty.

Since nearly all areas are farmed and watered extensively and its hydro chemical effects must be understood. For almost two decades this region has been exposed to excessive inorganic fertilisers. These operations may produce huge amounts in agricultural regions The ionic potassium and nitrate concentrations of certain wells is usually greater than residential wells in agricultural areas. In this research region inside the Tanks and away from the human population, residential wells are usually built.

HYDROGEOCHEMICAL PROCESS

The chemical composition of the water results from hydrogeochemical processes happening in the groundwater zone via interactions with aquifer minerals. Geochemical processes are extremely essential in controlling the groundwater composition of the aquifer system. The seasonal and geographical fluctuation in the quality of soil water, as mentioned above, is responsible for geochemical reactions. During their flow from the recharge region, the geochemical process alters the groundwater quality. The geochemistry of water in the recharge area as well as subsurface training influence the geochemical characteristics of different ground water bodies. The many geochemical processes responsible for the chemical nature of this region's groundwater.

MIXING OF SURFACE AND GROUNDWATER

In this zone, river, tanks and ponds are the major surface water resource sources. Water samples have been taken from surface water bodies situated in the research region in order to detect the interaction between surface water and groundwater. The chemical components of these samples were examined. The findings confirm that the surface water and groundwater are mixed. The comparison between pond and well groundwater quality is comparable. This shows the impact of recharging the pools in the area leading to soil with low total solids dissolved. In general, stocking in a pond will take 4 months after monsoon begins.

LITERATURE REVIEW

Ahamed et al., (2015) The quality and groundwater evaluation of the Amaravathi basin of the Karur district were studied. There is excessive salt and it is not safe for drinking in the water samples. This is because, for the past 11 years, tannery colouring, municipal and farm waste have continuously merged directly with the river.

Hussain et al., (2014) Water hardness has been found to rely mostly on calcium and magnesium salt amounts. In groundwater samples from Karur, Tamilnadu, the total hardness levels ranged between 552 and 2700 ppm. The overall hardness levels at all sample sites exceed the desired WHO limit (300ppm) owing to the presence of Ca and Mg bicarbonates and chlorides and sulphates. High hardness levels induce cardiac and renal problems. Hardness levels are high.

Sridhar et al., (2013) In Nagalkeni in the district of Kanchipuram, Tamilnadu, India, we examined the effect of leather and cosmetic businesses on groundwater quality. They discovered that the concentrations in Ca, Na, Cl, HCO3 and Mg exhibited in a number of locations indicating the effect of tannery waste effluents that were not treated properly on land and sewage systems. The current groundwater quality in this region may be improved via artificial refilling and rainfall collecting.

Nagaraju et al., (2014) Evaluation of the quality of soil water irrigation in the Guntur district of Andhra Pradesh mining area reported. Irrigation and industrial applications in groundwater research are among the most significant elements. Water is a good solvent which is necessary if dissolved components are to be analysed and if analysis findings are to be interpreted.

Vasanthavigar et al., (2012) Studied in Tamilnadu, a Thirumanimuttar river basin and discovered that during and after the monsoon seasons the hardness of groundwater was greater owing to untreated water and ion exchange processes.

Singh et al., (2015) the quality of the groundwater in Chandauli Varanasi, Uttar Pradesh has been assessed. There were collected and analyzed 70 groundwater samples. The findings have shown increased concentrations of main ions in all chemical parameters during the post-moonsoon season, with the greater level caused by surface pollution when rainfall was infiltrated and vertical percolations and limited areas of agricultural activity.

Brindha et al., (2012) In the district of Nalgonda, Andhra Pradesh, investigated the content of nitrate in soil water. The spectrum spans from BDL to 879.65 mg/L. The source of nitrate usually consists of nitrogen sediments, industrial wastes, soil rich in organic nitrogen, biological micro-organism fixation and inorganic nitrogen fertilisers. Having an accumulation of waste animal as large dumps in the population areas may be the primary cause for excessive nitrate concentration, as can be used for anthropic and sewage operations close to the wells.

Vasantrao et al., (2017) Did study Sier and Schlumberger techniques for groundwater research electrical resistivity, Dhule district, India. Did research. The curves are drawed from the 54 VES sounds using the Sier setup reverse slope technique. The Schlumberger setup was made use of IPI2 win software and matching curve methods. The results show that the unconfined aquifer may be found in Sakri with a mean depth between 10.6 and 12.2m, in Dhula 18.2 to 19.8m and in Shindkhenda 16.7 to 18.2m.

Sattar et al., (2016) the use of VES in Northwest Bangladesh investigated transmissivity and hydronic conductivity. The hydraulic conductivity ranges from 31 to 85 meters/day and the transmissibility in the studied region varies from 448 to 1,955 m2 per day. In the floodplain, transmissivity is high; in Barind, the floodplains have more potential for abstraction of groundwater.

Jaysena et al (2007) The hydrochemicals of the soil water flow in the crystalline soil and climate changes have been investigated, showing that they have an important influence in the hydrochemical behaviour of the region.

Ramesh and Elango (2005) the quality evaluation of groundwater in the Tondiar Basin was investigated. This is a heavily irrigated area with a large portion of the soil water being utilised for agriculture and the hydrogeochemical processes in the aquifer system must be understood.

Pathak et al (2004) the nitrogen leaching in the paddy field was investigated and the use of Nitrate leaching was described. High water and nitrogen crops tend to increase the danger of nitrate contamination.

OBJECTIVES OF THE STUDY

- To determine the causes seasonal and regional variations in groundwater main ion concentrations
- To identify groundwater's primary ion composition is controlled by a geochemical process.
- To identify groundwater's appropriateness for irrigation and domestic use

RESEARCH METHODOLOGY

Study Area

Manavalakurich Tamil Nadu is the study area of the research, during the pre-monsoon season of 2021, groundwater samples will be collected at random from 30 open wells and bore wells.

Sample Collection

High-density polyethylene bottles will be employed to collect the samples. To avoid reactivity with the atmosphere, the vials are quickly sealed after collecting the sample. The labeling of the sample bottles will be done in a systematic manner. In the lab, the gathered materials will be examined for several physicochemical properties. During the process of collecting, processing, preserving, and analyzing samples.

Using a Hanna multi-parameter probe, the pH and electrical conductivity (EC) will be measured in situ, as well as the main ions (Ca2+, Mg2+, Na+, K+, HCO−3HCO3−, SO2−4SO42−, Cl−) will be analyzed in the laboratory using the standard methods. Among the analyzed ions, sodium (Na+) and potassium (K+) will be determined using flame photometer. Calcium (Ca2+), magnesium (Mg2+), bicarbonate (HCO−3) (HCO3−) and chloride (Cl−) will be analyzed by volumetric methods and sulfate (SO2−4)(SO42−) Spectrophotometer has been estimated. For the quality testing of the groundwater will be the piper diagram, the Gibbs plot, Wilcox diagram and the USSL plot.

Data Analysis

The ArcGIS 9.3 programme will be used for the geographical investigation of several physicochemical characteristics. For digitization and analysis of soil water quality assurance data, ArcGis 9.3 software will be employed. In spatially interpolating data and estimating the values between measurements will be a weighted reverse distance (IDW) algorithm.

RESULTS AND DISCUSSION

The analysis results will be examined to identify the adequacy of the groundwater for drinking and farming applications in the field of investigation. Comparing the results achieved with the World Health Organisation (WHO) and the Indian Standard Institute by several aspects of water quality (ISI). The levels and performance of major ions, including Ca2+, Mg2+, Na+, K+, HCO−3HCO3−, SO2−4SO42−and Cl− as also certain physiochemical and physiological parameter such as pH, EC, TDS and soil water appropriateness are described below:

pH: The equilibrium between hydrogen ion and hydroxyl ion concentration in water is called pH. The pH value limit for potable water is 6.5–8.5. (WHO; ISI). In various forms of geochemical balance or solubility calculations, the pH of water gives crucial information. The pH value of most groundwater samples in the research region varies from 5.3 to 7.4, which clearly demonstrates a mild acidic character of groundwater in the study area.

Electrical conductivity (EC): EC is an electric power measurement of water capacity. In potable water, the most ideal EC limit is 1500 μS/cm (WHO). In the research region, the EC of the groundwater varied between 67.2 and 2771.8 μS/cm, averaging 819 μS/cm. Higher EC shows salt enrichment in ground water in a few groundwater samples. EC can be an approximate index of the total dissolved material concentration in water.

Calcium and magnesium: The calcium ions (Ca2+) content of ground water samples varies from 0.5 to 118.2 mg/L (average value of 39.1 mg/L) to 6.4 to 124.2 mg/L (Average value of 34.3 mg/l) and magnesium ions (Mg2+). Detrital minerals such as plagioclase feldspar, pyroxen, amphibole and grenade are the main sources of calcium and magnesium in most groundwater samples. Calcium and magnesium are also increased in the groundwater by calcareous, dolomite, gypsum, anhydrates and clay minerals in the sedimentary rocks of coastal areas.

Sodium and potassium: Sodium ion concentrations (Na+) vary between 18 and 560 mg/l in collected soilwater samples. The highest permitted salt limit is 200 mg/l and the present analysis shows just a small number of samples surpass the allowed WHO and ISI limits. High Na+ groundwater is not appropriate for agricultural usage as it tends to degrade soil. Potassium is an element that occurs naturally, although its concentration is considerably lower than Ca2+, Mg2+ and Na+. It seldom surpasses 20 mg/l in potable water. K+ levels in the groundwater of the study region range from 0.5 mg to 83 mg/l.

Chloride: Concentrations of chloride ion (Cl−) in soil water samples obtained vary from 21.3 to 756.2 mg/l, the mean value being 169.7 mg/l. The maximum allowed chloride concentration in groundwater is 600 mg/l, in accordance with the WHO guidelines. One of the indications of marine intrusion is the increasing content of chloride in a freshwater aquifer.

Bicarbonate: The HCO−3HCO3− values found are between 110 and 549 mg/l in groundwater settings. For the bulk of the samples, bicarbonate is the dominating anion, except for few samples obtained in the vicinity of the shore. The increased HCO−3HCO3− concentrations in water reveal the dominance of dissolving minerals.

Sulfate: The sulphate concentration (SO2−4SO42−) varies between 2 and 78.5 mg/l with a mean value of 34.3 mg/l. The reduction, preclusion, solution and concentration by the sedimentary rock such as gypsum and anhydrite are a high sulphate content in the groundwater. Their value is high. The concentration of sulphates is within the WHO and ISI limits in the region under examination.

Total dissolved solids (TDS): TDS is desired to be the greatest in groundwater up to 500 mg/l and up to 1000 mg/l is acceptable in accordance with WHO criteria. TDS values range from at least 41.6 mg/l to a maximum of 1775 mg/l for the study region. For water purposes, 60% of the entire groundwater sample within the region under investigation should be drunk (TDS < 500 mg/l), 23.3% should be consumed (500-1000mg/l), and 16.6 percent should be irrigated. The TDS categorization of groundwater samples should be performed.

Hydro geochemical facies: By ploting the concentrations of large cations and anions in the piper trilinear diagram, the geochemical development of groundwater may be shown. The type and distribution of hydrochemical faces can be established through an understanding into how the quality of groundwater in and between aquifers changes. Trilinear diagrams may be used to delineate hydrogeochemical processes as the connections between the most essential dissolved components in a collection of groundwater samples are visually demonstrated. The concentrations of the main cations (Ca2+, Mg2+, Na+ and K+) and anions (HCO-3HCO-3, SO2-4SO42– and Cl−) in meq/l will be used to evaluate the hydro geochemistry in the studied region.

Sodium percentage: Sodium is typically referred to as the proportion of sodium or sodium in irrigation fluids. A typical measure for assessing its adequacy for irrigation purposes is Na percent in all natural waters. In the following equation, sodium percent values (Na percent) are obtained:

Na%=Na+×100/ (Ca2++Mg2++Na++K+),

where all ionic concentrations are expressed in meq/l.

Sodium absorption ratio: Sodium absorption ratio (SAR) is a measure of the suitability of groundwater for irrigation usage, because sodium concentration can reduce the soil permeability and soil structure. SAR is a measure of alkali/sodium hazard to crops and is estimated by the following formula:

SAR=Na+/ [(Ca2++Mg2+)/2]0.5,

Where the concentrations of sodium, calcium and magnesium are in meq/l.

USSL plot

The US Salinity Laboratory (USSL) has established a graphic for irrigation water classification, detailing sixteen classes using SAR as sodium hazard index and EC as salinity risk index. The USSL diagram shows that 33% of samples fall within the C3S1 field, indicating a high salinity water level and a low alkaline sodium risk. Three of the C4S3, C3S3, and C3S2 categories indicate a high to a very high danger for salinity and a medium to high hazard for sodium, while the rest of the samples are covered with low and medium-salin and sodium hazards in the C2S1 and C1S1 regions.

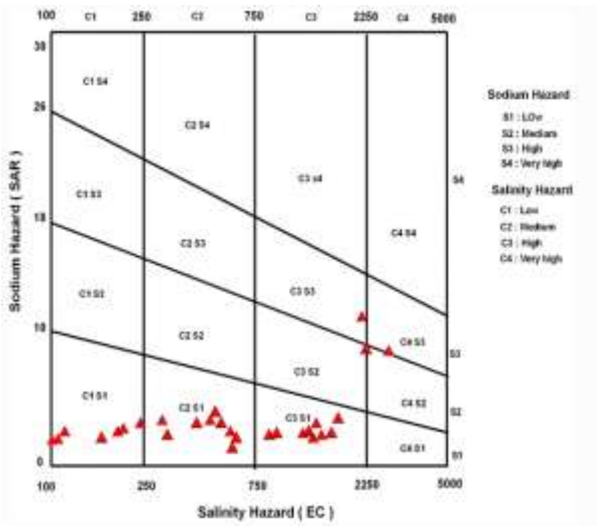

Figure 2: USSL diagram representing the salinity and sodium hazard

Wilcox diagram

WILCOX classifies groundwater for irrigation by associating sodium with EC, indicating that 60% of the total 30 samples fall below a high to good threshold and that 30% fall below a high to allowable threshold. Only 10% of the samples (W1, W25 and W26) are under the dubious limit that shows that groundwater from these wells is not appropriate for farm use.

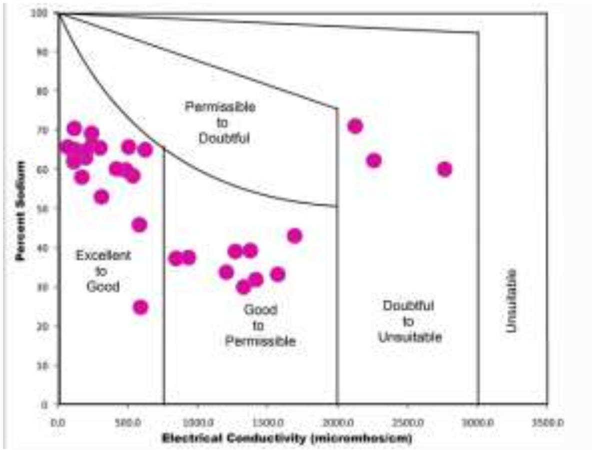

Figure 3: Suitability of groundwater for irrigation in Wilcox diagram

CONCLUSION

Groundwater contamination is typically the result of poor quality of drinking water, water losses, high expenses for cleaning up water, costly alternative suppliers of water, and possible health problems. The study shows that the groundwater in the studied region is of a somewhat acidic character by interpreting the hystero-chemical analysis. The sequence of the abundance of the major cations is $Na^+ > Ca^{2+} > Mg^{2+} > K^+$ and The $Cl^- > HCO^-_3 > SO^{2-}_4 Cl^- > HCO_3^- > SO_4^{2-}$ anion is anonymous. Sodium and chloride, which demonstrate the salty character of ground water in some places, are the major cation and anion respectively. The main hydro geochemical processes responsible for the concentration of significant ions in soil water are the rocks weathering and processes of evaporation. The analyses of drinking water quality reveal that the groundwater from the W25 and W26 wells is not suitable for drinking because ion levels are more than the permitted limitations. The categorization of groundwater based on its irrigation appropriateness also shows that water wells W1, W25 and W26 cannot be used for irrigating. Thus, the ground water from the W1, W25 and W26 wells was determined to be harder in the study region from the 30 well sampling analyzed. Natural salty water intrusion and also manmade activities might be responsible for the hazardous character of soil water.

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