SPATIAL DISTRIBUTION OF PHYSICO-CHEMICAL PARAMETERS AND HEAVY METALS OF GROUNDWATER IN AND AROUND KANCHIPURAM TOWN, TAMIL NADU, INDIA

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ABSTRACT

Groundwater is an important resource that contributes highly to the total annual supply and also most significant natural resource required by humans for a secure and healthy living environment. However, groundwater is now contaminated due to a variety of factors such as urbanisation and industry. The present study is to check or analyse the water quality in and around the Kanchipuram district due to presence of highly populated and developing area with high potential for pollution. Groundwater samples were taken from the bore well and open well at twenty distinct places. The collected samples were tested for the Physico-chemical test such as pH, Electrical Conductivity, Chloride, Total Hardness, Total Dissolved Solids, Calcium, Magnesium, Fluoride, Turbidity, Total Alkalinity, Iron, Nitrate, Nitrite, Free Ammonia, heavy metals such as Copper, Lead, Chromium, Cadmium, Zinc, the results were compared to BIS. The result revealed that GIS-based analysis has been carried out to find the spatial distribution of various parameters in the well stations.

Keywords: Groundwater, Physical parameters, Chemical parameters, Heavy metals, Permissible limits

1 INTRODUCTION

Groundwater plays a very significant role in the supply of water for human activities [1]. Groundwater quality is important for determining its use for domestic, irrigation and industrial purposes [2]. The groundwater chemistry could reveal important information on the geological history of the aquifers and the suitability of groundwater for domestic, industrial and agricultural purposes [3]. Like many natural resources, groundwater is being exploited at an increasing rate all over the world. Generally, groundwater is preferred as a main source of drinking water or potable water in the whole world because availability of water and natural protection from pollution. It is main purpose used for domestic, irrigation and also industrial needs. A lack of proper understanding of the groundwater system, in terms of resource utilization, is one of the major limitations to the effective management of groundwater resources [4]. Groundwater is the principal source that has been used for drinking and agricultural purposes in many places of the world. Evaporation, deposition, dissolution and weathering of minerals, ion exchange, and other geochemical processes that occur in the groundwater system are all responsible for seasonal and regional changes in groundwater chemistry. Groundwater quality is critical for determining the usability of groundwater for agricultural, household, and industrial purposes [5]. Anthropogenic factors will also have an impact on groundwater quality. The geological formation, climate, pollution, and drainage conditions all have an impact on groundwater quality. Groundwater is normally neutral to alkaline. If toxins are present in the groundwater, it cannot be used for drinking or irrigation.

Data interpretation can be used to compare water quality standards as well as the relationship between water quality and environmental data. The most important natural resource essential for a human being for a secure and healthy living source is groundwater [6]. But nowadays the groundwater is contaminated by different reasons like urbanization and industrialization. Changes in groundwater quality are being caused by rock–water interaction and oxidation-reduction processes that occur during water percolation in aquifers. Groundwater quality varies depending on location, depth of the water table, season, and the amount of composition of dissolved particles. Because of the interaction of groundwater with various materials in geologic layers, larger quantities of dissolved components are found in groundwater than in surface water [7]. The chemical composition of groundwater is an essential parameter for evaluating the quality of the water. Water quality is critical and is frequently deteriorated due to agricultural, industrial, and human activities. As a result, a water quality monitoring system is required to receive information on changes in water quality. The main objectives of the study are to study the quality variations in the groundwater based on the analytical data obtained from the groundwater samples using GIS.

3 MATERIALS AND METHODS

3.1 Study Area

Kanchipuram city is placed in the south-west path at a distance of 76 km from Chennai. It is located at 11˚00' to 12˚00' North latitudes and 77˚28' to 78˚50' East longitudes. The district is bordered by Chennai to the north and Vellore city to the south. The district east side borders the Bay of Bengal, with Vellore and Tiruvannamalai districts on the west. The elevation of the district ranges from 2m to 83m (275 ft) with a gradual downward slope towards the sea. The area is classified under Seismic Zone II. In and around Kanchipuram area has 4393.37 Sq. Kms and a coastline of 57 Km. the district is drained by Palaru, Vegavathi, and Cheyyar and other small rivers. Palaru river is the main source of water for Kanchipuram city.

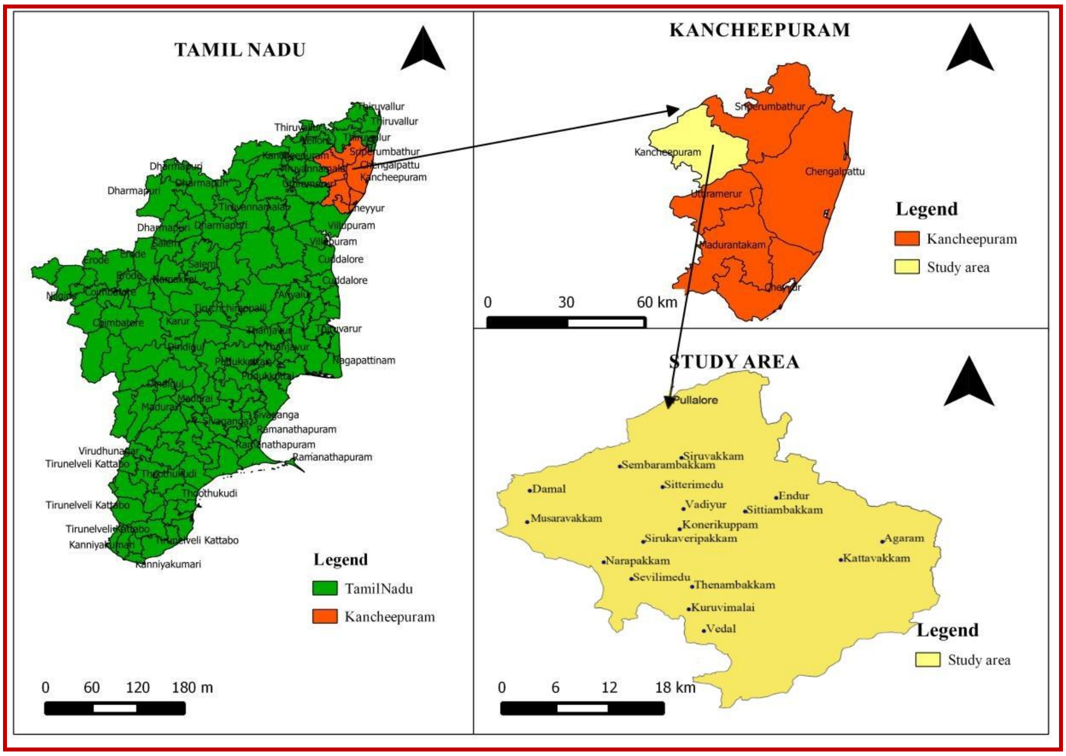

Figure 1. Location Map of the Study Area

3.2 Methodology

The selection of monitoring wells to collect groundwater samples is important for assessing groundwater quality. For the collecting of water samples, twenty samplings were chosen using Google Earth. The samples were gathered in January 2022, during the pre-monsoon season. ArcGIS software is used to create a base map of the study area as shown in Figure 1. Samples were tested, and the results were recorded. Electrical conductivity, pH, TDS, EC, Total Alkalinity, Calcium, Magnesium, Sodium, Potassium, Sulphate, Chloride, Nitrate, Nitrite, Fluoride, Free Ammonia, Total Hardness, Phosphate and heavy metals such as Cadmium, Copper, Zinc, Lead, Chromium. These findings were matched to Bureau of Indian Standards (BIS) guidelines. ArcGIS software was used to create thematic maps of the various physicochemical parameters.

Table 1. Statistical Analysis for physico-chemical parameters and heavy metals

Parameters	BIS Standard	Max	Min	Mean
pH	6.5-8.5	7.47	6.58	7.073
Electrical conductivity micro mho/cm	1500	3400	810	1819.45
Total dissolved solids mg/l	1500	2380	567	1275.4
Total Alkalinity as $CaCO_3$ mg/l	200	464	204	339.3
Total hardness as $CaCO_3$ mg/l	200	588	272	432.4
Calcium, mg/l	75	126	54	88.15
Magnesium, mg/l	30	72	14	50.8
Free ammonia, mg/l	0.5	5.45	0	1.171

Nitrite as mg/l	10	0.24	0	0.059
Nitrate as mg/l	45	20	0	13.8
Chloride, mg/l	250	640	105	278.5
Fluoride, mg/l	1.0	1	0.4	0.66
Sulphate mg/l	200	339	52	160.25
Phosphate, mg/l	0.025	0.25	0	0.07
Cadmium, mg/l	0.003	0.086	0.005	0.01847
Chromium, mg/l	0.05	0.25	0.08	0.1555
Copper, mg/l	0.05	4	0.16	1.1395
Lead, mg/l	0.01	0.131	0.015	0.06065
Zinc, mg/l	5	11	0.23	0.0405

5. RESULTS & DISCUSSION

Groundwater quality maps are useful in assessing the usability of the water for a different purpose. Figures show the spatial distribution of physical and chemical concentrations and heavy metals in the study area. A groundwater quality map is generated for each parameter following.

pH

The pH scale is a numerical scale that describes the degree of acidity or alkalinity of a solution and is represented by the equation pH=log1/aH+ = -log aH+, or, in other words, pH can be defined as the negative logarithm of hydrogen ion concentrations [8]. The general range of pH in the ground water in the study region ranges from 6.58 to 7.47, and the area has been categorised into 4 classes, as shown in Figure 2.

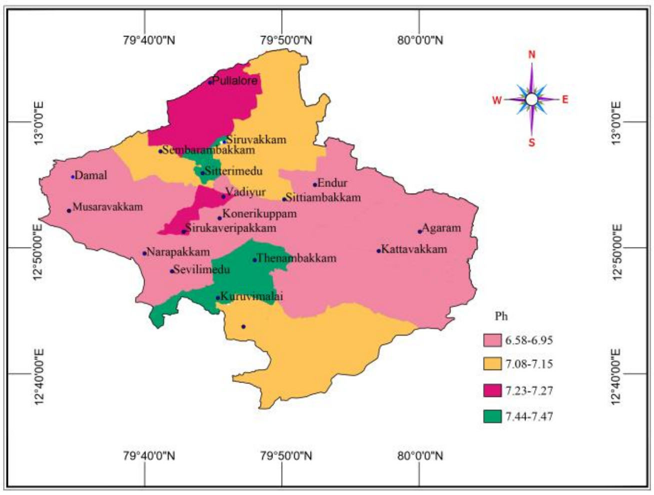

Figure 2. pH

Electrical Conductivity (EC)

Electrical conductivity is defined as a solution's ability to conduct an electric current and is measured in micro mhos/cm and reported at 250 degrees Celsius. Electrical concavity is determined by ion concentration, charge, and iconic mobility [9]. Electrical conductivity is roughly indicative of iconic strength. The EC in the research region runs from 810 to 3400, and the area has been divided into six groups, as illustrated in Figure 3.

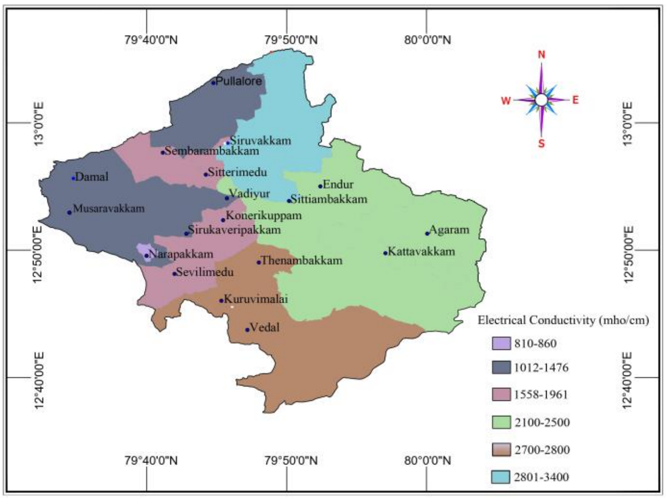

Figure 3. Electrical Conductivity

Total dissolved Solids (TDS)

The concentration of dissolved solids in natural water is usually less than 500 mg/L, while water with more than 500 mg/L is undesirable for drinking and many industrial uses. Water with TDS less than 300 mg/L is desirable for the dyeing of clothes. Water with high dissolved solid content would therefore be expected to pose problems like taste, laxatives and other associated problems with the individual minerals. If the water contains less than 500 mg/L of dissolved solids, it is generally satisfactory for domestic use and many industrial purposes. Normally, water with greater than 1000mg/L of dissolved solids usually presence of disagreeable taste or unsuitable in other respects. It was reported that a maximum TDS value of 2380 mg/L is the desirable limit and 2000 mg/L is the maximum permissible limit and that water containing more than 500 mg/L of TDS causes gastrointestinal irritation [10]. To determine the suitability of groundwater for any purpose, it is important to classify the groundwater depending on its hydro chemical properties based on its TDS values, which are represented in Figure 4.

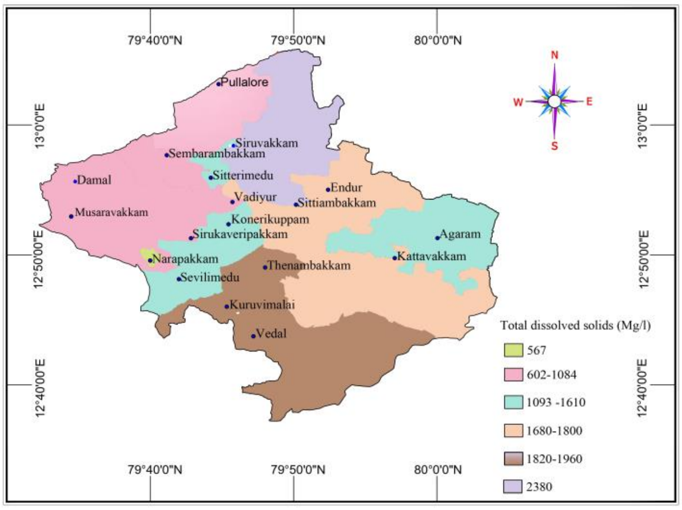

Figure 4. Total Dissolved Solids

Calcium

Calcium is a major component in many rocks. Calcium minerals are found in the presence of sodium, aluminium, silica, sulphate, carbonate, and fluoride. Calcium has a maximum allowable value of 75 mg/l [11]. Figure 5 shows the classification of the study area into five classes.

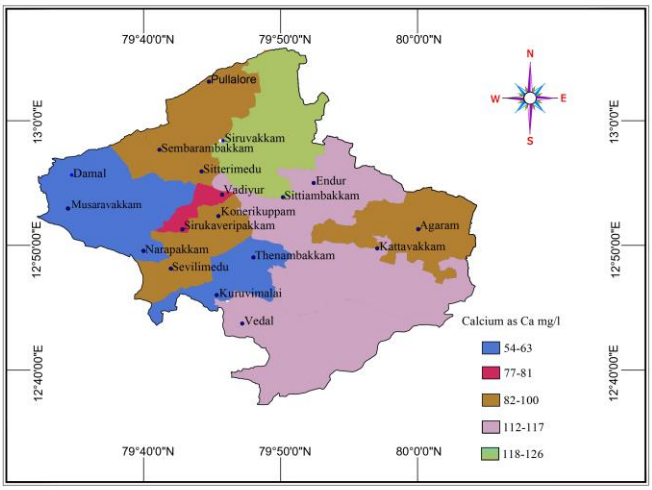

Figure 5. Calcium

Magnesium

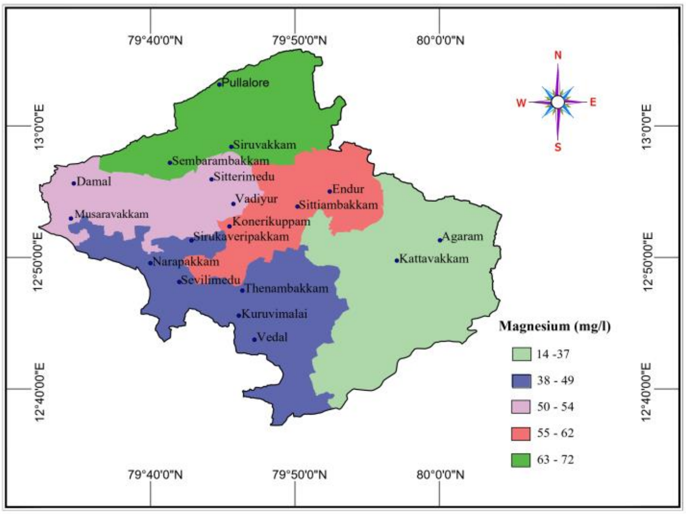

Figure 6. Magnesium

Magnesium hardness values ranged from 14 to 72 mg/l as presented in Figure 6.

Chloride

Chloride is a trace element found in the earth's crust. Rainwater contains less than one part per million of chloride. Unless the water is brackish or saline, its concentration in natural water is usually less than 100mg/l. A high chloride concentration imparts a salty flavour to water and beverages and may cause physiological damage [12]. Water with a high chloride level has an unpleasant taste and may be unsuitable for several agricultural applications.

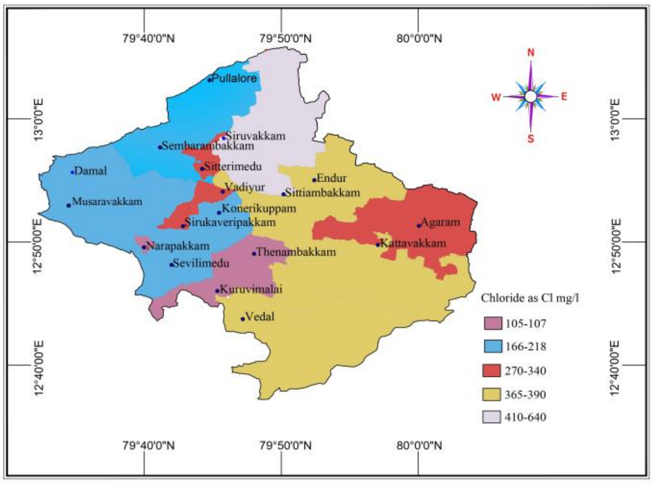

Figure 7. Chloride

The level of chloride taste perception is variable from person to person but is generally of the order of 250mg/l. Chloride is also relatively free from the effects of exchange adsorption and biological activity [13]. Overall, the chloride distributions in the studied regions are below the specified limits in several locations and are unsuitable in 5 of 20 as shown in Figure 8.

Nitrate

In recent years, the problem of groundwater contamination by nitrates has been studied thoroughly all over the world. The concentration of nitrate in the presence of natural water is lower than 10 mg/L. Water containing more than 100 mg/L is bitter to taste and causes physiological distress. Nitrate compounds are very soluble, and nitrate is removed from natural water only by the activity of organisms or evaporation, finally reaching groundwater [14]. Nitrate in groundwater is typically derived through sewage effluents, septic tanks, and natural drains that convey city garbage. For 8 of the 20 samples, the nitrate concentration was less than 16 mg/L as shown in Figure 8. Empirical evidence suggests that the nitrate distributions in the research areas are within the permitted limits, but are not drinkable and must be treated before supply.

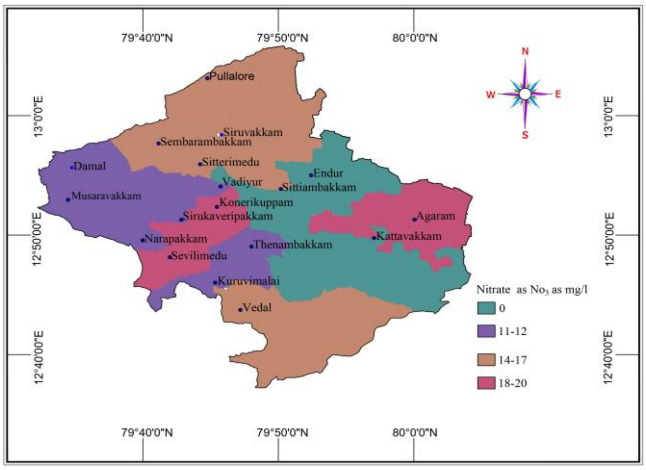

Figure 8. Nitrate

Nitrite

The permissible limit of nitrite ranges from 0 to 0.1 mg/l. The nitrite amount in groundwater is low, it reaches high levels due to runoff from agricultural land and contamination from human and animal wastes as significance of the oxidation of ammonia and parallel sources. Anaerobic conditions may result in the formation and persistence of nitrite as shown in Figure 9.

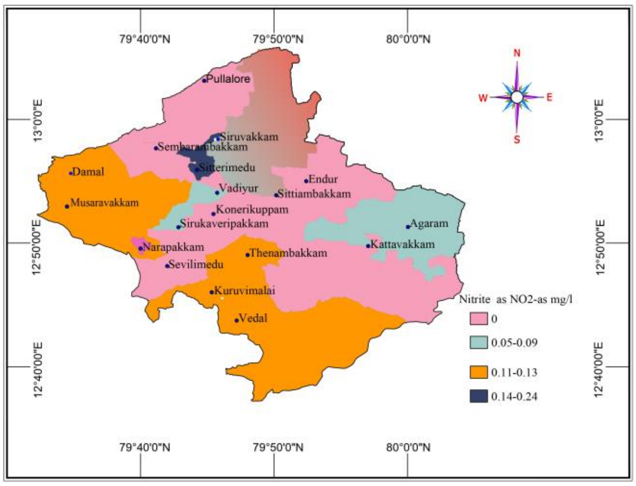

Figure 9. Nitrite

Free Ammonia

The levels of ammonia in groundwater from all parts of the sample stations are found to be in the range of 0 – 5.45 mg/l as shown in Figure 10. Natural causes of ammonia contain the decomposition of biological waste matter, gas conversation with the air, jungle fires, human and animal waste, and nitrogen fixation methods.

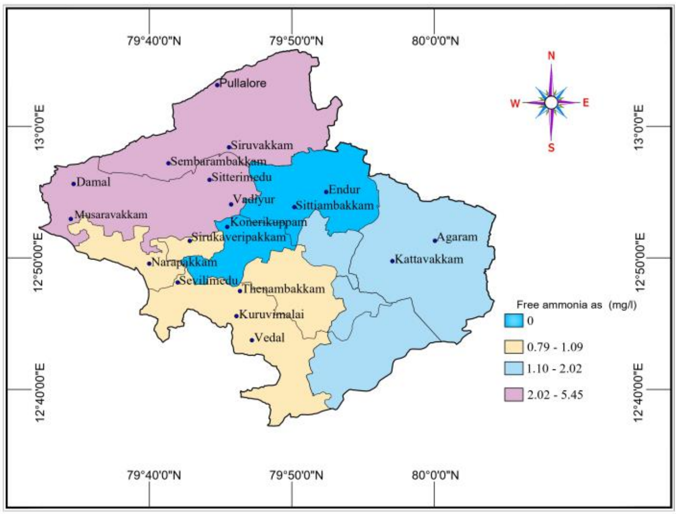

Figure 10. Free Ammonia

Total Hardness

The total hardness of water may be divided into 2 types, carbonate or temporary and bi-carbonate or permanent hardness. The hardness caused mainly by the sulphates and chlorates of calcium and magnesium cannot be removed by boiling which is called permanent hardness. The total hardness categorization of groundwater in the research area, demonstrates that the bulk of the samples fell into the extremely hard water category[15]. The values for hardness vary from 272 to 588 mg/L as shown in Figure 11. All of the groundwater in the current study region is classified as hard to very hard and must be processed before usage.

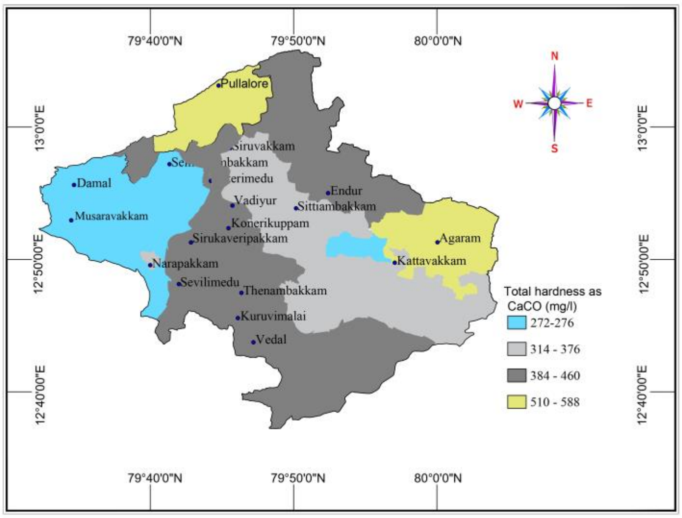

Figure 11. Total Hardness

Sulphate

Sulphates were classified into five ranges (52-85, 86-111, 112-158, 159-231, 232-339 mg/l), Based on these parameters, a spatial variation map for sulphates was created and is as shown in Figure 12. Sulphate concentrations in water samples varied from 52 to 339 mg/l. The geographical variation map revealed that the sulphates vales in the northern half of the research area are in bad ranges (>300 mg/l). The sulphate value in the southern half of the research region is moderate to good.

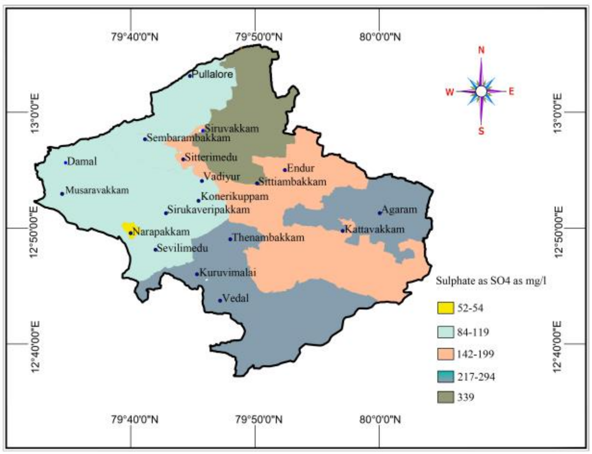

Figure 12. Sulphate

Phosphate

The levels of phosphate in groundwater from all parts of the sample stations are found to be in the range of 0 – 0.25 mg/l as shown in Figure 13. Greater concentration of phosphate due to the usage of detergents for washing of garments and utensil activities by the residents in and around the dug wells.

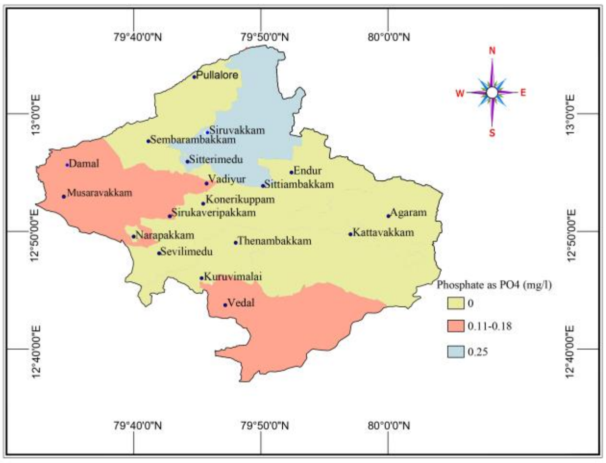

Figure 13. Phosphate

Copper

Like brass and bronze, copper is a pliable metallic element that is widely utilised as an electrical conductor. Industries including steel, plastic, and blast furnaces contribute to the build-up of copper in water. The accepted value of Cu in drinking water is 1.5 mg/l. In the study area the concentration of copper ranged from 0.16 to 4 mg/l as shown in Figure 14.

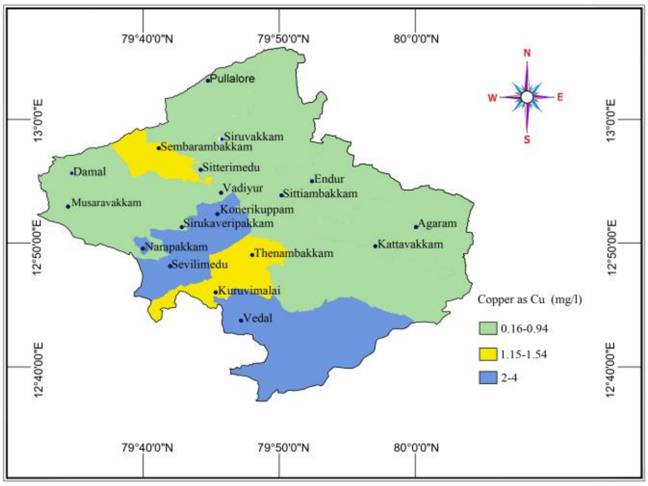

Figure 14. Copper

Cadmium

A small metallic element called cadmium is found naturally in the waters and crust of the earth. It serves as a pigment for steel plating that is resistant to corrosion and stabilises plastic. It is recognised that exposure to specific cadmium forms and quantities can have harmful effects on people. The permissible limit of Cadmium in drinking water is 0.003 mg/l. The below figure 15 shows a range between 0.005 to 0.086 mg/l in Kanchipuram region. All the samples are contained above the permissible limit.

Lead

Lead is a heavy metal from the carbon family that is mostly utilised in the production of lead-acid storage batteries. Smelting, motor vehicle exhaust gases, and lead pipe corrosion are other sources of lead leakage. A high concentration Pb (0.015 – 0.131 mg/l) as shown in Figure 16 was recorded in our study area. All the samples are exceeded the permissible limit 0.01 mg/l.

Chromium

Chromium molecules react to soil, contaminating it ultimately. The potential health risks include liver and kidney damage, skin inflammation, and ulceration. The concentration of Cr in the Kanchipuram region is ranged between 0.08 to 0.25 mg/l as shown in Figure 17. In which all of the samples exceeded the permissible limit 0.05 mg/l as per standard.

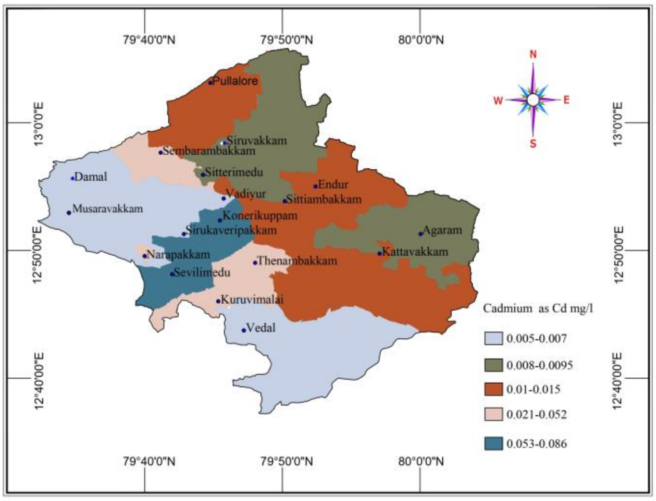

Figure 15. Cadmium

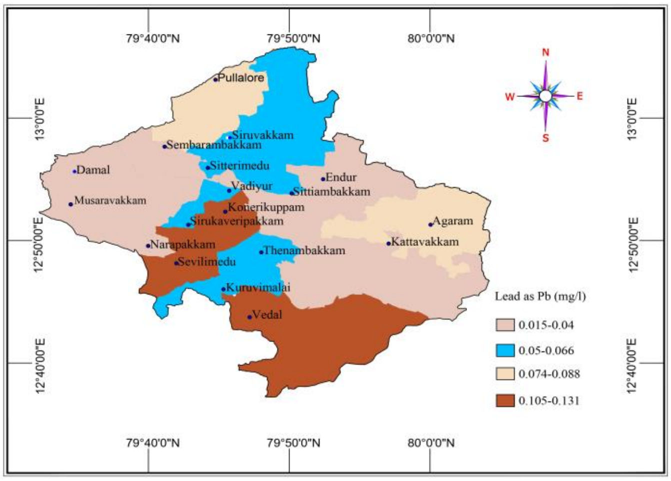

Figure 16. Lead

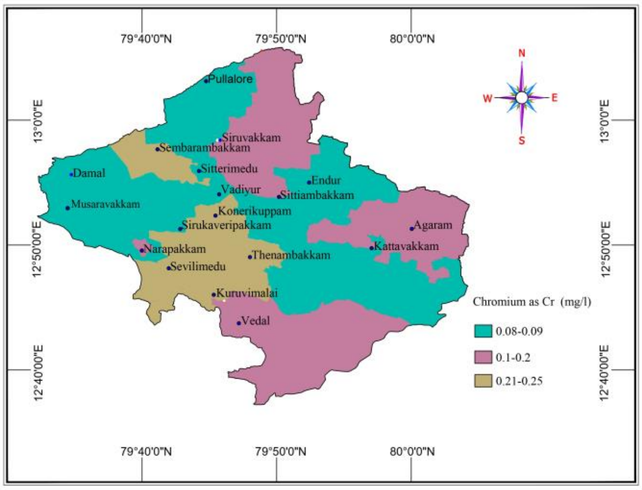

Figure 17. Chromium

Zinc (Zn)

The concentration of zinc in the study area varied between 0.23 to 11 mg/l shown in Figure 18 and 50% of the samples exceeded the permissible limit 5 mg/l.

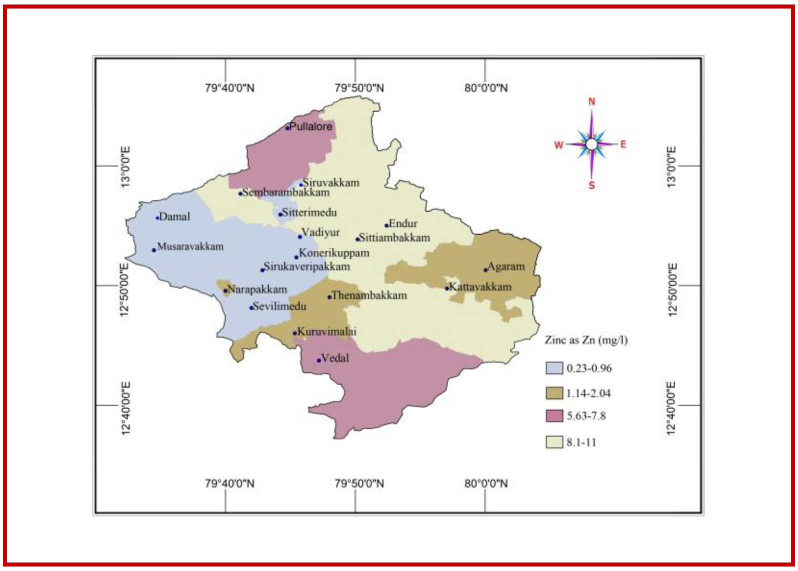

Figure 18. Zinc

CONCLUSION

The current study attempted to examine and develop a map of the Kanchipuram district's groundwater quality. Groundwater quality in and around Kanchipuram area shows high mineral contents in terms of total dissolved solids, total hardness, calcium, magnesium, nitrate, chloride, fluoride, iron and sulphate, phosphate and heavy metals are exceeded the permissible limit as per standards. The reason for higher values of physico-chemical parameters at certain sampling locations may be due the unscientific disposal of solid wastes, the depth of the wells and nature of the geological materials with which the groundwater comes in contact may influence the quality of the water. The results revealed that groundwater of the study area in some locations are not suitable for drinking purposes due to the presence of heavy metals.

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