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## RESEARCH ARTICLE

# WATER QUALITY FOR DRINKING PURPOSES USING GPS IN SOME MAJOR COASTAL AREAS OF NAGAPATTINAM DISTRICT-SOUTH INDIA

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**ABSTRACT**

Groundwater samples have been collected from 105 various location of major costal area, 35 revenue village of sirkali Taluk of Nagapattinam district, Tamil Nadu, India and these samples were used to assess the water quality for drinking purposes. The study area is sirkahi Taluk of Nagapattinam district coastal region in the southern Tamilnadu State located in the coastal region of Bay of Bengal 11.02903730N Latitude and 79.85068150 E Longitude. The physico-chemical parameters of groundwater like pH, Electrical conductivity (EC),Total dissolved solids (TDS) Total hardness (TH), Ca, Mg, Na, K, $SO_4$,Cl, $CO_3$, $HCO_3$, Zn, Mn, Cu and Fe were determined. The values were analyzed and compared with World Health Organization (WHO) water quality standards and Bureau of Indian Standards (BIS). Suitable groundwater quality zones for drinking purpose were identified through GPS system.



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## INTRODUCTION

Water is one of the indispensable that support all forms of life (Vanloon and Duffy, 2005). Contamination of water have been a major connection of health problems particularly in the developing countries (UL-Haq *et al.,* 2011). Water is an indispensible and basic element which supports life and the natural environment, a prime component for industry, a consumer item for human beings and animals and a vector for domestic and industrial pollution (Arabi *et al.,* 2010). The natural water analysis for physical, chemical properties including trace element contents are very important for public health studies. These studies are also a main bit of pollution studies in the environment (Vanloon and Duffy, 2005; UL-Haq *et al.,* 2011; Shri, 2011; Martin-Gonzalez *et al.,* 2006; Hussein *et al.,* 2015; Gardea-Torresdey *et al.,* 2005). Also, investigations of the quality of drinking water samples have been continuously performed by researchers around the world. Heavy metals are one of the most interminable pollutants in water.

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Unlike other pollutants, they are difficult to degrade and can cumulate producing potential human risks and ecological disturbances (Shri *et al.,* 2011). Heavy metals adventure and accumulation in the environment is as a result of direct or indirect human activities such as rapid industrialization, urbanization and anthropogenic sources (Martin-Gonzalez *et al.,* 2006; Hussein *et al.,* 2015; Gardea-Torresdey *et al.,* 2005). Heavy metals can affect our bodies in a multitude of negative ways (Adepoju-Bellow *et al.,* 2005; Gaur *et al.,* 2012), they can disrupt our energy producing pathways in the body, they have an affinity for the central nervous system and nerve cells, they bind to blood cells impairing them, they are deposited in kidney, bones, liver and most organs of the body, causing organ damage, they attempt with nutritional metals for binding hormones that control our endocrine and reproductive functions. The results of these actions includes fatigue, memory loss, attention loss, weight loss, irreversible neurological damage, tremor, insomnia, depression, anemia, low blood pressure and a host of other symptoms. Some elements like Fe, Zn, Cu, Mn are needed in small quantities for human metabolism but may be toxic at higher levels (Shri *et al*., 2011). The determinations in drinking water have been performed using classical analytical techniques including

Titrimetric, Gravimetric and modern instrumental techniques such as atomic absorption spectrometry (AAS), Flame photometric, Digital conductometric, Digital pH meter, etc study evaluated the heavy metals contamination in underground waters from some major coastal area of Nagapattinam Distric, Tamilnadu, South India.

## MATERIALS AND METHODS

### *Study Area*

Nagapattinam district, the land of religious harmony, known for its rich religious heritage was carved out by bifurcating the composite Thanjavur district on 18-10-1991. This district is spread over eight taluks with a total geographical extent of 2715.83 sq.km with the head Quarters at Nagapattinam. This district lies on the shores of Bay of Bengal between Northern Latitude 10.7906 degrees and 79.8428 degrees Eastern Longitude. The district capital 'Nagapattinam' Lies on the eastern coast, 350 kilometers down south from the state capital 'Chennai' and 145 kilometers east, from Tiruchirappalli a central place of the state. The study area is sirkahi taluk of Nagapattinam district coastal region in the southern Tamilnadu State located in the coastal region of Bay of Bengal 11.0290373 Latitude and 79.8506815 Longitude. This taluk is spread over in 27,726 hectares of Agriculture land. Fig.1 shows the study area.

### *Water Sampling*

Totally 105 water sample were collected near costal area of thirty five revenue village by using white color polystyrene bottle of one liter capacities. Before collecting the samples, the bottle were washed properly and rinsed thoroughly several times with same underground water. Each samples were labeled with correct GPS location and address for analysis purpose. The underground water sample were collected of location data shown in Table Then the quality of underground water analyzed in the laboratory determined many parameters such as pH, EC,TDS, Ca, Mg, Na, K, $SO_4$,Cl, $CO_3$, $HCO_3$, Zn, Mn, Cu and Fe are determined by standard methods and by using standard instruments. Then the water quality results are compared with standard values Recommended by Bureau of Indian Standards (BIS) for drinking purpose.

### Global Positioning System (GPS) System

The GPS surveying techniques were used to identify the specific location of various underground waters samples situated at different villages of the coastal area Table 1. Since the Global positioning systems (GPS) is an integral part of topographic surveys. The GPS datasets were originally stored as point measurement. Each point had northing, easting and elevation values.

### *Methodology*

The collected samples were determined by using standard methods (Table 1) with standard instrument.

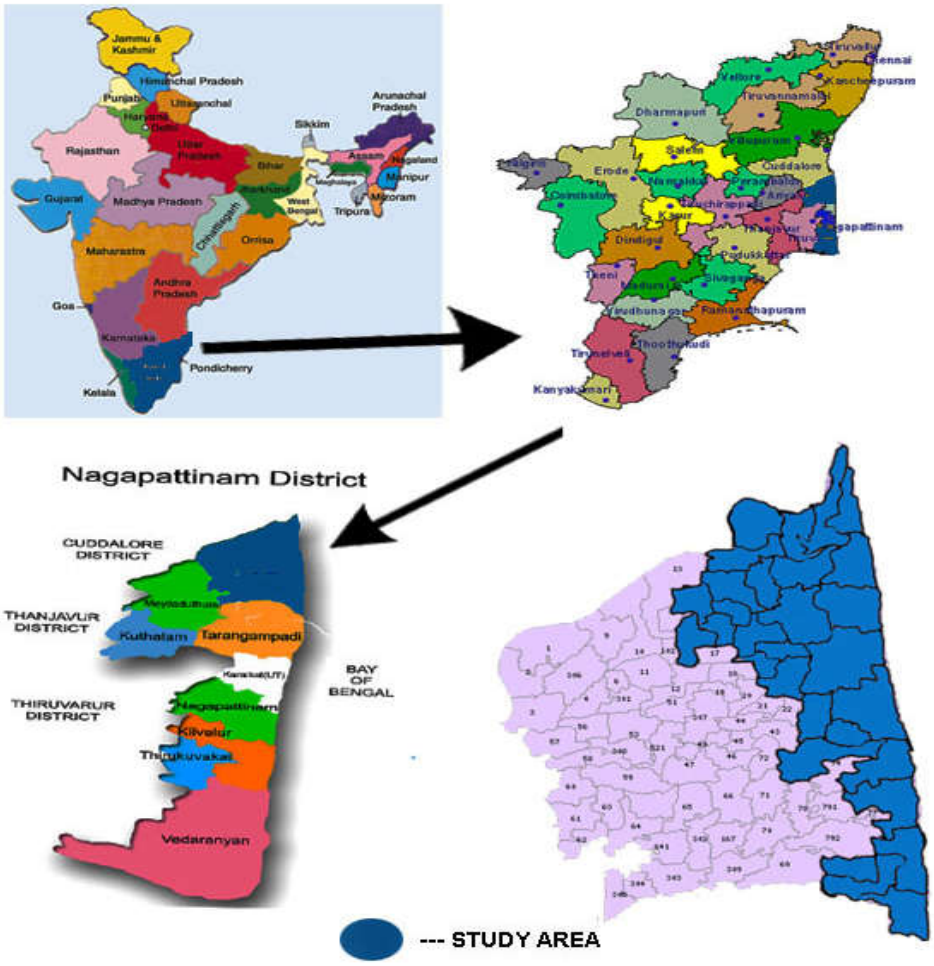



**Fig. 1. Location map of sample collected costal area of sirkazhi Taluk -Tamilnadu**

## RESULTS AND DISCUSSION

Suitability of groundwater for drinking water quality assessment was carried to determine its suitability in terms of drinking purposes based on the world health organization and Bureau of Indian Standards (Table 6).

**Table 1. GPS Location data of sample collected coastal area of Nagapattinam District**

| S.No | Village name | Sample-1 location | | Sample-2 location | | Sample-3 location | |
|---|---|---|---|---|---|---|---|
| | | LONGITUTE$^0$ E | LATITUTE$^0$N | LONGITUTE$^0$ E | LATITUTE$^0$N | LONGITUTE$^0$E | LATITUTE$^0$N |
| 1 | Alakudi | 79.7.69122 | 11.374512 | 79.7098206 | 11.3468035 | 79.7130885 | 11.383628 |
| 2 | Mehentrapalli | 79$^0$.767089 | 11.3552895 | 79.792311 | 11.365823 | 79.790460 | 11.363629 |
| 3 | Puthupattinam | 79.8131648 | 11.3193474 | 79.810300 | 11.331299 | 79.811824 | 11.331363 |
| 4 | Mudhalai medu | 79.7513063 | 11.3305297 | 79.7591976 | 11.3429095 | 79.769434 | 11.350886 |
| 5 | Aarapallam | 79.7591976 | 11.3429095 | 79.7670123 | 11.3550131 | 79.7532172 | 11.3401644 |
| 6 | Puliyandhurai | 79.8136559 | 11.348863 | 79.767089 | 11.3552895 | 79.7642389 | 11.3521932 |
| 7 | Thandavangulam | 79.8131648 | 11.3193474 | 79.799558 | 11.2806557 | 79.807361 | 11.303528 |
| 8 | Pazhaiyapalaiyam | 79.7792386 | 11.288338 | 79.8065089 | 11.3157187 | 79.7877799 | 11.2934519 |
| 9 | Maadhanam | 79.7513063 | 11.3305297 | 79.758874007 | 11.29835216 | 79.766153 | 11.298055 |
| 10 | Kattur | 79.7131821 | 11.4113457 | 79.8136559 | 11.348863 | 79.7776476 | 11.3922826 |
| 11 | Aharavattaram | 79.774278 | 11.2896393 | 79.7767583 | 11.2889887 | 79.7792386 | 11.288338 |
| 12 | Maharajapuram | 74.7792386 | 11.288335 | 79.8157375 | 11.24777415 | 79.7746362 | 11.2936038 |
| 13 | Vettangudi | 79.7860874 | 11.2702060 | 79.79207 | 11.2520318 | 79.7792678 | 11.2883813 |
| 14 | Alangadu | 79.755763 | 11.2483195 | 79.750619 | 11.2483021 | 79.7706846 | 11.2581747 |
| 15 | Kadavasal | 79.79207 | 11.2520318 | 79.79281 | 11.2520420 | 79.7838591 | 11.252372 |
| 16 | Varisaipathu vadakal | 79.7792678 | 11.2883813 | 79.78815 | 11.253912 | 79.784243 | 11.255267 |
| 17 | Thirumullai vasal | 79.8192325 | 11.2403698 | 79.8106432 | 11.2289728 | 79.7934645 | 11.2061788 |
| 18 | Edamanal | 79.7706846 | 11.2581747 | 79.7690291 | 11.2510061 | 79.7706846 | 11.2581747 |
| 19 | Radhanallur | 79.8192325 | 11.2403698 | 79.8060697 | 11.2462008 | 79.8204342 | 11.2410063 |
| 20 | Thirukaraikkayur | 79.7772445 | 11.2374523 | 79.7672145 | 11.2481231 | 79.7823418 | 11.223541 |
| 21 | Thirunahari | 79.8192325 | 11.2403698 | 79.7964963 | 11.2097911 | 79.787469 | 11.2096313 |
| 22 | Thennampattinam | 79.8033508 | 11.2255006 | 79.787459 | 11.2096313 | 79.8140009 | 11.2179338 |
| 23 | Nepathur | 79.7934645 | 11.2061785 | 79.7435231 | 11.2062341 | 79.7904667 | 11.2079051 |
| 24 | Mangaimadam | 79.80857159 | 11.18948806 | 79.81176731 | 11.18950784 | 79.804993 | 11.194661 |
| 25 | Muthal perunhottam | 79.83082618 | 11.20162288 | 79.83132686 | 11.20140694 | 79.831363828 | 11.20139480 |
| 26 | Irandamperunthottam | 79.831584109 | 11.8315841094 | 79.83175132100 | 11.201277066 | 79.82829158655 | 11.19562215 |
| 27 | Ahara perunthottam | 79.822035 | 11.189204 | 79.822654 | 11.185583 | 79.824159 | 11.184741 |
| 28 | Manikiramam | 79.824556 | 11.1452993 | 79.8199747 | 11.1488791 | 79.8199747 | 11.1488791 |
| 29 | Melaiyur | 79.8199747 | 11.1468791 | 79.8053401 | 11.1844758 | 79.8392016 | 11.1567777 |
| 30 | Keezhaiyur | 79.8392016 | 11.156777 | 79.8392016 | 11.1567777 | 79.8392016 | 11.1567771 |
| 31 | Vanakiri | 79.8291373 | 11.1417196 | 79.8291373 | 11.1417196 | 79.83991615 | 11.1453899 |
| 32 | Alalasuntharam | 79.797515067 | 11.31897286 | 79.752399731 | 11.318646898 | 79.74312963142 | 11.31824321 |
| 33 | Achalapuram | 79.7254736 | 11.3099142 | 79.7564412 | 11.3289478 | 79.7532767758 | 11.32667577 |
| 34 | Nallanayakka puram | 79.74282631 | 11.31834750 | 79.742739482 | 11.31843785 | 79.742584143 | 11.31835203 |
| 35 | Umaiyal pettai | 79.7713634 | 11.2584211 | 79.7713634 | 11.2584211 | 79.764766 | 11.264640 |

**Table 2. Summarized the methods used to analyzed the physico-chemical parameters in groundwater samples of the region**

| Parameters | Methods |
|---|---|
| pH | Digital pH meter |
| E.C | Conductivity meter |
| TDS | Calculation method |
| Total Hardness | Calculation method |
| $CO_3$,$HCO_3$,Cl,$SO_4$ | Titrimetric mehods and specrophotomertric methods |
| Ca,Na,K,Mg | Flame photometer and Titrimetric methods |
| ZN,Fe,Cu,Mn | Atomic absorption spectroscopy |

**Table 3. Water quality based on Total Hardness (TH mg/l)**

| Total Hardness | Indication |
|---|---|
| 0 to 60 mg/l | Soft water |
| 60 to 120 mg/l | Moderately hard water |
| 120 to 180 mg/l | Hard water |
| >180 mg/l | Very hard water |

**Table 4. Some Health impact of parameters**

| PARAMETES | HEALTH IMPACT |
|---|---|
| pH | Bitter taste, corrosion, affects mucous membrane |
| Total dissolved solids | Gastrointestinal irritations, undesirable taste |
| Hardness (Calcium + Magnesium) | Scale forming, skin irritations |
| Sulphate | Laxative effect, Gastrointestinal irritation Chloride Corrosion |
| Sodium | Vomiting, nuverseness, heart disease |
| Potassium | Dehydration, type 1 diabetes, Addison's disease, internal bleeding |
| Calcium | Bone cancer, over active thyroidgl and (hyperthyroidism), overactive para thyroid (hyperparathyroidism) |
| Megnesium | Hyper tention, cardiovascular, osteoporosis, migraine headache |
| Copper | Liver damage, mucosal irritation, renal damage and depression, restricts growth of aquatic plants |
| Iron | Anemia, liver disease, same cancer, hair, nail teeth problem |
| Manganease | Blood clotting skin problem, neurologicalproblem, brith defects |
| Zinc | Gastrointestinal, dehydration |

**Table 5. World health organization (WHO) and Bureau of Indian Standards (BIS) allowable standard Values to Drinking Water**

| Parameters | pH | EC uS/cm | TDS mg/l | T.H mg/l | Cl meq/l | SO4 meq/l | Ca meq/l | Mg meq/l | Na meq/l | K meq/l | Zn ppm | Cu ppm | Fe ppm | Mn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BIS | 6.5-8.5 | 500 | 500 | 300 | 7.042 | 4.166 | 3.5 | 2.5 | 8.7 | 0.307 | 0.153 | 0.0015 | 0.01074 | 0.0072 |
| WHO | 6.5– 8.5 | 500 | 500 | 300 | 7.042 | 4.166 | 3.5 | 2.5 | 8.7 | 0.307 | 0.153 | 0.0015 | 0.01074 | 0.0072 |

***pH***

The pH is a measure of the hydrogen ion concentration in water. The pH value of water shows whether the water is acidic or alkaline. Drinking water with a pH range of 6.5 to 8.5 is generally considered satisfactory (WHO, BIS). Acid water go to be corrosive to plumbing and faucets, particularly, if the pH is below 6. Alkaline waters are slight corrosive; water with a pH above 8.5 may tend to have a bitter or soda-like taste. In the study area, the concentration of hydrogen ion (pH) ranges between 7.25-8.18 with a mean of 7.76 (Table 6). All the water samples analyzed have concentration within the safe limit of 6.5 to 8.5 standard set by the (WHO, BIS) (Table 5). If pH is not within the permissible limit, it damages mucous membrane present in nose, mouth, eye, abdomen, anus in human beings (Ramesh and Soorya, 2012).

***Total hardness as $CaCO_3$***

Total hardness (TH) is caused primarily by the presence of cations such as calcium and magnesium and anions such as carbonate, bicarbonate, chloride and sulphate in water. Water hardness has no known adverse effects; howbeit, some evidence indicates its role in heart diseases, (Schroeder, 1960). Drinking water with the hardness range of 180 mg/l is generally considered satisfactory (WHO, BIS) and above may cause kidney problems and kidney stone formation, as it causes unpleasant taste and reduce ability of soap to produce lather. Hard water is unsuitable for domestic use. In the study area, the total hardness varies between 289-665 mg/l with a mean 439.914mg/l (Table 6). All the samples are very hard water and has unsatisfied the limit of 150 mg/L.

***Chloride ($Cl^-$)***

Chloride is present in all natural waters, usually in relatively small amounts; however, chloride also can be derived from human sources. Chloride is a major ion that is associated with Individual Septic Disposal System. In the study area, the chloride range between 2.3-15.4meq/l with a mean of 7.5meq/l (Table 6). The maximum allowable concentration of 7.0422 meq/l (NWQS, 2007). Excess chloride above the background levels may be due to groundwater contamination as a result of seepage from septic systems, landfill, fertilizers or animals. Excess concentration of chloride in drinking water gives a salty taste and has a laxative effect on people not accustomed to it (Bhardwaj and Singh, 2010). Chloride imparts a salty taste and some times higher consumption causes the crucial for the development of essential hypertension, risk for stroke, left ventricular hypertension, osteoporosis, renal stones and asthma in human beings (McCarthy, 2004). Although, the chloride plays an important role in balancing the level of electrolyte in blood plasma, but higher concentration can produce some physical disorders.

***Sulphate ($SO4^{2-}$)***

Sulphate occurs in water as the inorganic sulphate salts as well as dissolved gas. The concentration of sulphate ($SO4^{2-}$) in the present study the values are very low and ranged between 066-0.773 with the mean value of 0.273 meq/l(Table.6) and the values are within the maximum allowable limits of 100 mg/L according to WHO, BIS standards. The high concentration of sulphate in some places is likely due to the dissolution of gypsum, which underlies the area. According to Raghunath, sulfate causes gastrointestinal irritation if it exceeds 250 mg/l level. The excess of sulfate (more than 250 mg/l) may also be the reason for bitter taste and may have laxative effect to human beings and livestock at further higher level (WHO, 1984). Very high levels of sulfates have been associated with some brain disorders in livestock.

***Calcium ($Ca^{2+}$)***

Calcium contributes to the hardness of water and it is the fifth most common element found in most natural waters. The sources of calcium in ground water especially in sedimentary rocks are calcite, aragonite, gypsum and anhydride. In the study area, the concentration of calcium in groundwater is low and ranged between 2.9933-7.733 meq/l with the mean of 4.605 (Table 6) which is below the maximum allowable concentration of 3.75 meq/lit (NWQS, 2007). From health point of view, calcium may be excess, it causes bone cancer, hyperthyroidism and hyperparathyroidism.

***Magnesium ($Mg^{2+}$)***

Magnesium contributes to the hardness of water and it is one of the most common elements found in the earth's crust. It is present in all natural waters. The sources of magnesium in natural water are dolomites and magic minerals (amphibole) in rocks. The solubility of dolomite in water depends on the composition. In the study area, magnesium concentration ranged between 2.16-7.14 meq/l with the mean of 4.195 meq/l (Table 6). The maximum allowable concentration 2.5 meq/lit (BIS and WHO). Whenever the concentration level excess, it is due to some health problem, such as Hyper tension, cardiovascular, osteoporosis, migraine headache.

***Potassium ($K^+$)***

Potassium is an essential element for humans, plants and animals, and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. In study area, potassium concentration ranged between -0.01-0.133 meq/l with the mean of 0.042 meq/l (Table 6) which is lower than the maximum allowable concentration of 0.307 meq/l based on (WHO, BIS) standards for drinking water. Though potassium is extensively found in some of igneous and sedimentary rocks, its concentration in natural waters is usually quite low. This is due to the fact that potassium minerals offer resistance to weathering and dissolution.

***Sodium ($Na^+$)***

Sodium is common constituents of natural waters. Sources of sodium are halite, sea spray, some silicate and rare minerals such as plagioclase, plagioclase variety of albeit and nepheline. Most sodium results from natural ion exchange.

**Table 6. Average mean value of water quality parameters of coastal areas of Nagapattinam District**

| S. No | Village name | T.S | pH | EC (dsm-1) | TDS | T.H mg/l | ANIONS/(meq/lit) | | | | CATIONS/(meq/lit) | | | | HEAVY METALS (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $CO_3$ | $HCO_3$ | Cl | $SO_4$ | Ca | Mg | Na | K | Zn | Cu | Fe | Mn |
| 1 | Alakudi | 3 | 7.85 | 2.033 | 1301.33 | 521 | 0.1 | 9.9233 | 10.166 | 0.1733 | 4.196 | 6.236 | 9.72 | 0.25 | 0.0366 | 0.02 | 0.0666 | 0.0166 |
| 2 | Mehentrapalli | 3 | 7.69 | 1.693 | 1083.66 | 621 | … | 9.9233 | 7.606 | 0.1066 | 6.033 | 6.4 | 4.463 | .0766 | 0.02 | 0.0366 | 0.1066 | 0.0366 |
| 3 | Puthupattinam | 3 | 7.76 | 2.226 | 1421.66 | 538 | …. | 8.8 | 13.166 | 0.3433 | 6.233 | 4.533 | 10.95 | 0.0966 | 0.0133 | 0.0266 | 0.0733 | 0.03 |
| 4 | Mudhalai medu | 3 | 7.713 | 1.533 | 981 | 448 | …. | 5.5066 | 6.42 | 0.2066 | 5.003 | 3.956 | 6.386 | 0.1333 | 0.0333 | 0.0266 | 0.09 | 0.0266 |
| 5 | Aarapallam | 3 | 8.056 | 1.47 | 940.66 | 453 | 0.333 | 5.54 | 8.7 | 0.1866 | 3.866 | 5.196 | 5.94 | 0.1166 | 0.0333 | 0.0266 | 0.0733 | 0.02 |
| 6 | Puliyandhurai | 3 | 7.676 | 1.776 | 1137 | 589 | …. | 8.966 | 8.766 | 0.1533 | 4.646 | 7.146 | 5.876 | 0.1133 | 0.04 | 0.0333 | 0.0866 | 0.02 |
| 7 | Thandavangulam | 3 | 7.716 | 1.05 | 671.66 | 325 | 0.1333 | 7.033 | 3.1 | 0.25 | 3.733 | 2.766 | 3.993 | 0.02 | 0.04 | 0.0366 | 0.1133 | 0.0366 |
| 8 | Pazhaiyapalaiyam | 3 | 7.833 | 2.39 | 1529.66 | 471 | 0.2 | 7.966 | 15.4 | 0.3466 | 5 | 4.433 | 14.456 | 0.0266 | 0.0333 | 0.0833 | 0.0733 | 0.03 |
| 9 | Maadhanam | 3 | 8.18 | 1.03 | 659 | 298 | … | 6.3 | 3.766 | 0.25 | 3.633 | 2.333 | 4.333 | 0.0166 | 0.04 | 0.0833 | 0.09 | 0.03 |
| 10 | Kattur | 3 | 7.753 | 1.43 | 915.33 | 665 | …. | 6.633 | 7.266 | 0.25 | 7.733 | 5.566 | 3.41 | 0.0133 | 0.0466 | 0.02 | 0.08 | 0.0133 |
| 11 | Aharavattaram | 3 | 7.593 | 1.166 | 746.66 | 313 | …. | 7.166 | 4.3 | 0.2166 | 3.533 | 2.733 | 5.396 | 0.0166 | 0.0433 | 0.0366 | 0.09 | 0.0366 |
| 12 | Maharajapuram | 3 | 7.853 | 1.843 | 1179.33 | 408 | … | 9.466 | 8.7 | 0.2833 | 4.3 | 3.866 | 10.26 | 0.02 | 0.04 | 0.0366 | 0.07 | 0.0233 |
| 13 | Vettangudi | 3 | 7.626 | 1.91 | 1222.33 | 628 | …. | 6.7 | 12 | 0.37 | 7.633 | 4.933 | 6.516 | 0.0166 | 0.03 | 0.0833 | 0.09 | 0.0466 |
| 14 | Alangadu | 3 | 7.846 | 1.17 | 751.33 | 293 | 0.1333 | 7.8 | 3.666 | 0.1066 | 3.133 | 2.733 | 5.833 | 0.02 | 0.0166 | 0.0766 | 0.0833 | 0.02 |
| 15 | Kadavasal | 3 | 7.676 | 0.946 | 605.66 | 306 | 0.0333 | 6.566 | 2.8 | 0.0666 | 3.133 | 3 | 3.333 | 0.0166 | 0.0333 | 0.08 | 0.06 | 0.04 |
| 16 | Varisaipathu vadakal | 3 | 7.96 | 0.923 | 591 | 289 | 0.2666 | 6.266 | 2.633 | 0.07 | 3.1 | 2.666 | 3.446 | 0.0166 | 0.0366 | 0.0333 | 0.12 | 0.0366 |
| 17 | Thirumullai vasal | 3 | 7.66 | 1.993 | 1276 | 530 | … | 7.033 | 13.833 | 0.7333 | 6.166 | 4.433 | 9.266 | 0.0166 | 0.03 | 0.02 | 0.1 | 0.02 |
| 18 | Edamanal | 3 | 7.916 | 0.993 | 635.66 | 298 | 0.2333 | 6.466 | 3.133 | 0.1066 | 3.8 | 2.166 | 3.966 | 0.0133 | 0.0333 | 0.0366 | 0.11 | 0.0266 |
| 19 | Radhanallur | 3 | 7.97 | 1.27 | 813 | 383 | 0.4333 | 6.7 | 5 | 0.5333 | 3.366 | 4.3 | 4.006 | 0.01 | 0.0433 | 0.0266 | 0.0866 | 0.0266 |
| 20 | Thirukaraikkayur | 3 | 7.9 | 1.426 | 912.66 | 510 | 0.8666 | 6.566 | 6.733 | 0.09 | 4.766 | 5.433 | 4.226 | 0.0166 | 0.0333 | 0.0266 | 0.06 | 0.0133 |
| 21 | Thirunahari | 3 | 7.63 | 1.533 | 994.33 | 520 | … | 7.466 | 7.333 | 0.58 | 5.733 | 4.666 | 5.1 | 0.0166 | 0.03 | 0.02 | 0.09 | 0.0133 |
| 22 | Thennampattinam | 3 | 7.91 | 2.043 | 1308 | 476 | 0.2666 | 8.666 | 11.333 | 0.1733 | 4.3 | 5.233 | 10.923 | 0.0266 | 0.0333 | 0.0266 | 0.0733 | 0.04 |
| 23 | Nepathur | 3 | 7.676 | 1.49 | 953.66 | 530 | … | 6.466 | 7.566 | 0.7733 | 5.5 | 5.1 | 4.296 | 0.0166 | 0.0233 | 0.04 | 0.07 | 0.0333 |
| 24 | Mangaimadam | 3 | 7.25 | 1.916 | 1226.66 | 450 | … | 9.433 | 9.333 | 0.4166 | 4.633 | 4.366 | 10.163 | 0.0233 | 0.0366 | 0.02 | 0.08 | 0.03 |
| 25 | Muthal perunhottam | 3 | 7.613 | 2.266 | 1450.66 | 497 | … | 9.633 | 12.6 | 0.4466 | 5.5 | 4.433 | 13.06 | 0.0233 | 0.0366 | 0.02 | 0.08 | 0.03 |
| 26 | Irandamperunthottam | 3 | 7.796 | 1.61 | 1030.33 | 423 | 0.2 | 9.6 | 6.1 | 0.2166 | 4.5 | 3.966 | 7.623 | 0.0233 | 0.03 | 0.07 | 0.1033 | 0.0366 |
| 27 | Ahara perunthottam | 3 | 7.77 | 2.1 | 1344 | 476 | 0.2 | 10.066 | 10.333 | 0.4166 | 5 | 4.533 | 11.46 | 0.02 | 0.04 | 0.0266 | 0.11 | 0.0166 |
| 28 | Manikiramam | 3 | 7.74 | 1.203 | 770.33 | 322 | 0.06 | 7.4 | 4.366 | 0.21 | 3.7 | 2.733 | 5.596 | 0.0166 | 0.0366 | 0.0266 | 0.08 | 0.03 |
| 29 | Melaiyur | 3 | 8.103 | 1.526 | 977 | 350 | 0.333 | 7.6 | 7.133 | 0.2033 | 4 | 3 | 8.27 | 0.0166 | 0.0166 | 0.05 | 0.0733 | 0.0366 |
| 30 | Keezhaiyur | 3 | 7.726 | 1.193 | 763.33 | 362 | 0.0333 | 7.833 | 3.966 | 0.1066 | 4.333 | 2.9 | 4.7 | 0.0233 | 0.0466 | 0.0266 | 0.09 | 0.0133 |
| 31 | Vanakiri | 3 | 7.786 | 1.636 | 1049 | 365 | 0.2666 | 9.4 | 6.633 | 0.14 | 4.133 | 3.166 | 9.096 | 0.0333 | 0.03 | 0.0266 | 0.0733 | 0.0266 |
| 32 | Alalasuntharam | 3 | 7.883 | 1.23 | 787 | 453 | 0.0666 | 6.233 | 5.8 | 0.21 | 2.9933 | 6.08 | 0.2 | 0.03 | 0.03 | 0.02 | 0.0766 | 0.02 |
| 33 | Achalapuram | 3 | 7.946 | 1.383 | 865.33 | 477 | … | 9.333 | 4.34 | 0.16 | 5.466 | 4.066 | 4.106 | 0.08 | 0.0233 | 0.02 | 0.07 | 0.0433 |
| 34 | Nallanayakka puram | 3 | 7.536 | 1.106 | 708 | 331 | … | 5.773 | 5.153 | 0.15 | 3.54 | 3.08 | 4.376 | 0.0966 | 0.0466 | 0.0266 | 0.0866 | 0.0166 |
| 35 | Umaiyal pettai | 3 | 7.556 | 2.373 | 1519 | 478 | 0.1666 | 10.033 | 13.133 | 0.42 | 4.866 | 4.7 | 14.156 | 0.02 | 0.0233 | 0.0266 | 0.07 | 0.0333 |

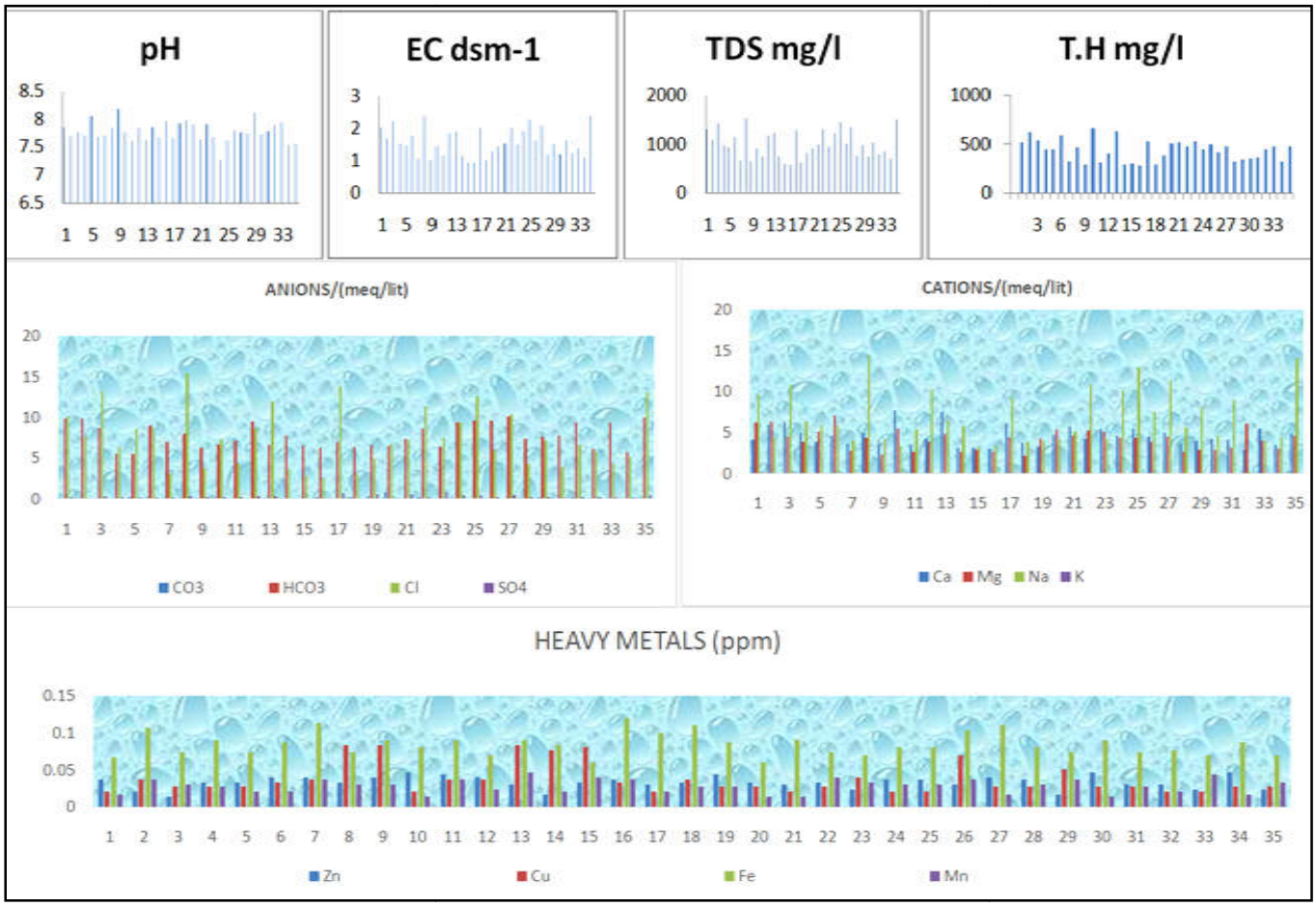
In the study area, the concentration of sodium in groundwater is low and ranged between 0.2-14.456 meq/l with a mean of 6.825 meq/l (Table 6) which is below the maximum allowable concentration of 200 mg/L (NWQS, 2007). From health point of view sodium have negative effects on people with heart disease. Sodium hydrogen carbonate mineral waters are important for treatment of gastric and biliary tract diseases.

***Iron ($Fe2^+$)***

Iron is a very common element found in many of the rocks and soils of the earth's crust. In the study area, the concentration of iron is between 0.06-0.12 ppm with a mean of 0.0426 ppm (Table 6) with the highest concentration value being 0.42 ppm and the maximum allowable concentration based on NWQS (NWQS, 2007) standard is 0.3 mg/L.

The source of this iron is probably due to the presence of ironstone, which dissolved into the ground water. Iron is biologically an important element which is essential to all organisms and present in hemoglobin system. High concentration causes slight toxicity, inky flavour, bitter and astringent taste. Iron contained water makes the teeth and nail black and weak, stickiness of hair and water. The shortage of iron causes a disease called anemia and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haermosiderosis (Vanloon and Duffy, 2005).

**Manganese (Mn2+):** In the study area, the concentration of manganese is between 0.0133 to 0.0466ppm with a mean of 0.02768 meq/l. (Table 6) with the highest concentration value being 0.42 ppm and the maximum allowable concentration based on BIS standard is 0.3 mg/L. High concentration causes brownish color, black stains on laundry, bitter taste.




**Figures 2. Average mean value of various water quality parameters of Sirkazhitaluk of Nagapattinam district**

***Copper (Cu $2^{+|}$)***

Copper is a reddish metal that occurs naturally in rock soil, water and air. It is an essential element for living organisms, including humans and in small amounts necessary in our diet to ensure good health. High concentration causes bitter or metallic taste, blue- green stains on plumbing fixtures. Copper can produce adverse health effects, including vomiting, anemia, digestive disturbances, diarrhea, stomach cramps and nausea. It has also been link with liver damage and kidney disease. In the study areas, the concentration of copper in ground water is ranged between 0.023 to 0.0833 meq/l, with a mean of 0.0370 meq/l (Table.6). Which is lower than the maximum allowable concentration of 0.05 meq/l.(BIS,WHO).

***Zinc (Zn$2^{+}$)***

Zinc is an needed element to humans, plants and animals. In the study area, The concentration of zinc in ground water is ranged between 0.0133 to 0.0466 meq/l, With a mean of 0.031144 meq/l. (Table 6). Which is lower than the maximum allowable concentration of 5 meq/l. Excess Zinc can causes adverse health effects including nausea, vomiting, and diarrhea, sometimes accompanied by bleeding and abdominal cramps (Elinder *et al.,* 1986).

***Conclusion***

The ground water quality of major coastal area of Nagapattinam district, south India has been assessed for drinking purpose the water quality resulted, the waters are not suitable to drinking purpose, because all area ground waters samples are not in acceptable standard values, some areas mostly affected by salinity water. Due to high level of calcium and magnesium. According to total hardness all are as ground waters are in very hard.

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