Published by
NIGERIAN SOCIETY OF PHYSICAL SCIENCES
Available online @ https://journal.nsps.org.ng/index.php/jnsps

J. Nig. Soc. Phys. Sci. 5 (2023) 1160

Journal of the Nigerian Society of Physical Sciences

Physico-Chemical and Trace Metal Analysis in Groundwater of Nagapattinam Region in Nagapattinam District of Tamilnadu State

C. Gopi[a,*], Edward Anand E[a], A. Charles[a], C. Manivannan[b], S. Ponsadai lakshmi[a], A. Jose[a], M. Muthiyan[c]

[a]*Department of Science and Humanities, E.G.S. Pillay Engineering College, Nagapattinam, Tamil Nadu, India.*
[b]*Department of Chemistry, puducherry Technological University, Puducherry, India.*
[c] *Research Scholar, Department of Chemistry, E.G.S. Pillay Arts & Science College, Nagapattinam, India.*

Abstract

The aim of the present work is to find the quality of water in and around the Nagapattinam region and geochemical study of water and its chemical composition with qualitative and quantitatively assessed from the period of post monsoon (January) in the year 2020. Therefore, ten underground water sample were taken from different areas in Nagapattinam region and analysed for the following qualities such as Color, odour, temperature, Electrical conductivity, total dissolved solid, Hydrogen ion Concentration, calcium, magnesium, chloride, potassium, sodium, nitrate, and sulphate and trace metals like manganese, lead, chromium, copper, iron, arsenic, cadmium and zinc. The physico chemical parameters indicate the quality of ground water varies from bore well to bore well. Higher values of any parameter in a borehole indicate that the water is not fit for drinking. Therefore, the public is advised that the groundwater source in the study area should be monitored before it is used for domestic and drinking water purposes and that the government should adopt some treatment technology in the current study regions to minimize the hardness and salinity for provide safe water to the public.

DOI:10.46481/jnsps.2023.1160

Keywords: Nagapattinam, Ground water, Monsoon, Physico-chemical parameters

Article History :
Received: 31 October 2022
Received in revised form: 05 January 2023
Accepted for publication: 10 January 2023
Published: 12 March 2023

Communicated by: Dr. K. Sakthipandi

1. Introduction

Groundwater plays an important role in the ecological functions of various ecosystems. Due to human activities, the groundwater system provides proper circulation for water recirculation; Water is being abused and contaminated in ordinary conceivable. This pollution causes water quality to decline. Half of the groundwater used in metropolitan areas in developing countries comes from wells and boreholes, and many in India rely on these resources. Contamination of heavy metals with its surrounding could be a major world concern, as a result of toxicity and threat to human life and ecosystem [1]. Heavy metals are superimposed with water system from artificial and natural sources [2]. Water quality is more important than quantity in any water. Groundwater's physical and chemi-

*Corresponding author tel. no: +91 9994648947
Email address: gopi@egspec.org (C. Gopi)

cal qualities support its use as a source of water for municipal, agricultural, and domestic purposes [3]. Nagapattinam district is a part of the South Indian state of Tamil Nadu, forming parts of the Cauvery River basins and Vennar sub-basins. Geographically, the district lies between latitudes 10°46′16″ and longitudes 79°50′50″78 as shown in Figure 1. From June to September starts south west monsoon and north east monsoon begins from October till January. Low rain fall observed in southwest period [4] from march to may summer start and end. It is one of the state's fastest growing cities, rapid urbanization and industry. Groundwater supplies have been put under a lot of strain as a result of urbanization. In the major part of the state, depth of the water level in pre-monsoon may 2019 is 2-5 m bgl and post monsoon January 2020 is greater than 2-5 m bgl shown in Figure 2.

2. Materials and Methods

In the post-monsoon period of 2020, water samples were taken from ten sample points in Nagapattinam and the surrounding area (January) in the depth of 40 Ft. APHA [5] was used to collect and analyze the samples. For drinking water, all of the settlements in the research region rely on groundwater. During the collecting and handling of the samples, all precautions were taken. Polyethylene containers were used to collect groundwater samples. The pH, electrical conductivity was determined on the spot using digital equipments after sampling. Water samples were analyzed for chemical parameters such Total Dissolved Solid, Electrical Conductivity, Hydrogen ion Concentration, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Bicarbonate, Nitrate, Phosphate, Sulfate and trace metals like Iron, Manganese, Chromium, Copper, Lead, Zinc and Cadmium.

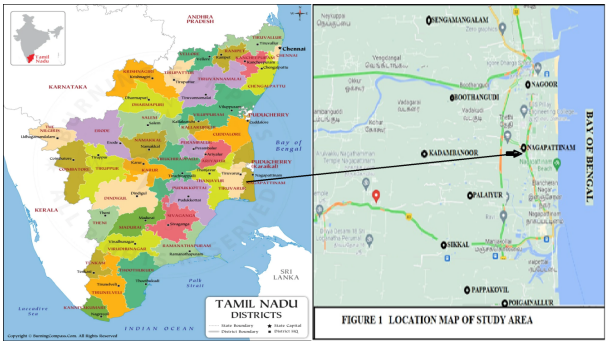

Figure 1: Location Map of Study Area

3. Results and Discussion

Table 1 lists the locations of ground water sampling stations in the research region. The analytical results of physical and chemical parameters of ground water were compared to the world health organizations 1985 standard guideline values for drinking and public health objectives Table 2.

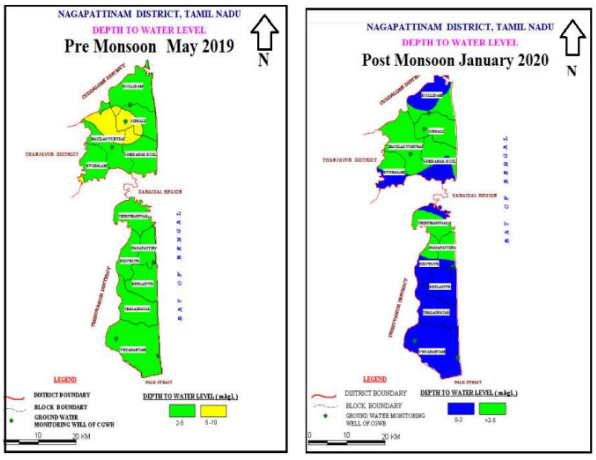

Figure 2: Peizometric surface data for Pre Monsoon and Post Monsoon Seasons

Table 1: Details of ground water sampling stations in the study area

S/N	Sampling stations	Sample ID	Source of water
1	Kadambanoor	S1	Bore well
2	Sengamangalam	S2	Bore well
3	Palaiyur	S3	Bore well
4	Boothangudi	S4	Bore well
5	Nagoore	S5	Bore well
6	Nagapattinam	S6	Bore well
7	Sikkal	S7	Bore well
8	Pappakovil	S8	Bore well
9	North Poigainallur	S9	Bore well
10	South Poigainallur	S10	Bore well

Table 2: WHO and BIS Standard of Drinking water

Parameters	WHO (48) (2011)	BIS 2012 (49)	Study Area Samples
	Permissible limit	Permissible limit	Min-Max (mg/L)
pH	6.5-8.5	6.5-8.5	6.5-8.7
EC	500-1500	-	590-1100
TDS	500-1500	500-2000	538-956
TH	100-500	200-600	246-722
Calcium	75-200	75-200	110-532
Magnesium	30-150	30	66-103
Magnesium	30-150	30	66-103
Sodium	50-200	-	86-180
Potassium	10-Dec	-	0.98-3.08
Chloride	250-600	250-1000	154-386
Bi carbonate	200-500	-	241-624
Sulphate	250-400	200-400	53-89
Phosphate	-	-	1.1-3.8
Nitrate	45	-	14-19

3.1. pH and Electrical Conductivity

pH is a measurement of a solution's acidity or felicity. It is defined as the co (H+) Hydrogen ion activity coefficient, which

Table 3: Physico-Chemical data of drinking water quality parameters of groundwater samples

Sample	pH	EC	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	NO_3^{-}	PO_4^{3-}	TDS	TH	SAR
S-1	6.8	600	350	96	180	1.1	289	256	82	14	1.1	742	615	53
S-2	7.8	700	270	82	155	1.37	352	289	78	15	3.2	853	262	56.9
S-3	7.3	850	327	103	114	1.27	262	456	73	15	2.8	924	551	61.6
S-4	8.7	590	220	92	126	0.98	275	241	89	16	3.1	950	246	59.4
S-5	6.5	1100	233	71	86	1.63	386	250	84	19	3.8	920	316	48.4
S-6	7.3	863	310	72	165	2.08	352	624	85	17	3.4	781	444	45.9
S-7	6.6	846	352	102	131	1.91	240	375	53	18	3.2	732	492	40.7
S-8	8.6	978	110	66	132	1.91	258	425	67	16	2.2	538	258	33.6
S-9	6.7	1005	402	75	172	3.08	154	562	72	19	2.1	676	535	35.6
S-10	7.5	630	532	98	124	1.64	356	342	83	19	2.6	956	722	50.3
Mini.	6.5	590	110	66	86	0.98	154	241	53	14	1.1	538	246	33.6
Maxi.	8.7	1100	532	103	180	3.08	386	624	89	19	3.8	956	722	61.6

Table 4: Correlation co- efficient values between the water quality parameters of groundwater samples in the study area during Monsoon 2020

Correlation	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	PO_4^{3-}	NO_3^{-}	pH	EC	TDS
Ca^{++}	1											
Mg^{++}	0.106	1										
Na^{+}	-0.374	-0.07	1									
K^{+}	0.0131	-0.29	0.497	1								
Cl^{-}	-0.032	-0.11	-0.35	-0.68	1							
HCO_3^{-}	-0.087	-0.31	0.367	0.573	-0.37	1						
SO_4^{2-}	-0.445	-0.17	0.002	-0.24	0.556	-0.24	1					
PO_4^{3-}	-0.251	-0.17	-0.6	-0.53	0.481	0.001	0.007	1				
NO_3^{-}	0.228	-0.23	-0.33	0.41	-0.01	0.231	-0.11	0.386	1			
pH	-0.03	-0.26	-0.03	-0.14	0.121	-0.11	0.45	-0.06	-0.4	1		
EC	0.219	-0.63	-0.31	0.293	-0.17	0.434	-0.35	0.303	0.487	-0.32	1	
TDS	0.204	-0.05	-0.48	-0.62	0.537	-0.42	0.57	0.467	0.078	0.044	-0.39	1

can only be calculated theoretically and cannot be measured empirically. The pH scale is a relative scale. It is relative to a set of standard solution which pH is established by international agreement. The pH level varied from 6.5 to 8.7. The maximum value found at S-4 and minimum value is mainly basic in nature [6]. The variation of electrical conductivity is 590 to 1100 μS/cm .In the minimum value found at S-4 and maximum value found at S-5 is within the desirable limit

3.2. Total Dissolved Solids

Total dissolved solids (TDS) indicate the salinity behavior of ground water sample. TDS values varied from 538 to 956. If TDS is more than 500 mg/L it is not suitable for drinking [7, 8, 9]. In the present study TDS values are higher than the prescribed limit given by WHO. The TDS concentration "found to be in above permissible limit may be due to the leaching of various pollutants into the ground water which can decrease the portability and this may results gastrointestinal irritation in human and also have laxative effect. High level of total dissolved solids may aesthetically be unsatisfactory for bathing and washing purposes" [10]. The TDS variation indicates a low concentration at S-8 and high concentration at S-10. TDS indicates that there is a low concentration of soluble salt in groundwater that is safe to drink. [11, 12, 13].

3.3. Total Hardness

The total hardness values are observed in the range of 246 to 722 mg/L Post Monsoon of 2020. Total hardness values are within the maximum permissible limit of world health organization in all the sample station except S-1 and S-10. This may be due to presence of bicarbonates, chloride and sulphates of Ca and Mg present in the water. The total hardness values are observed in the range of 246 to 722 mg/L Post Monsoon of 2020. Total hardness values are within the maximum permissible limit of world health organization in all the sample station except S-1 and S-10. This may be due to presence of bicarbonates, chloride and sulphates of Ca and Mg present in the water.

3.4. Chloride

Chloride ion is one the anion present in water and waste water as inorganic compound but chlorine in drinking water does not create harmful even at higher concentration it is harmless. If the concentration exceeds the maximum permissible limit it produces cathartic effect in the samples chlorine ranges from 154 mg/L to 386 mg/L. lower the concentration at S-9 and higher concentration at S-5. As a result, it has a high concentration in groundwater, where temperatures are high and rainfall is low. The porosity and permeability of the soil also play a role in raising the concentration of chlorides [10].

3.5. Nitrate

Concentration of nitrogen in groundwater in the range of 14 to 46 mg/L. it shows the site S-3, S-9 and S-10 are found higher concentration and other sites having lower concentration. But WHO limit for drinking water standard is 45 mg/L. Nitrate Concentration higher than this limit unfit for drinking .The present amount of concentration is mainly due to agricultural activities. The usage of larger quantity of nitrogen containing fertilizer in the land which may cause leaching from the root of the plants, soil and accumulate in water.

3.6. Sulphate

In adults, water containing 1000 mg/l magnesium sulphate serves as a purgative. (Bhagavathi Perumal and Thamarai [14, 15]. Sulphate occurring in water due to the municipal and industrial activity nearby discharge. Also human activity is one of the major anthropogenic attribute to runoff and rainfall. Concentration of sulphate varies from 53 mg/L to 89 mg/L. Low concentration observed at S-7 and high concentration S-4. The maximum permissible limit of sulphate in water is 400 mg/L.

3.7. Phosphate

Due to the activities of agriculture and Anthropogenic increase the phosphate content in water [16]. The phosphate concentration observed in the groundwater samples from the study area varied from Below Detection level of 1.1 mg/L. Phosphate found moderately low at many locations.

3.8. Calcium and Magnesium

The desirable quantity of calcium is 75mg/L. The Ca ionic concentration found low as 110 mg/L in sample station S-8 (532 mg/L at S-10) was observed high concentration but the permissible limit of calcium for water 200 mg/L. Except S-8 all other samples show above permissible limit. Due to low dissolution of magnesium the concentration is less in ground water than calcium [17]. The magnesium concentration is ranges from 66 to 103 mg/L where higher assessment found at S-3 and lower value found at sample station S-8. The acceptable limit of magnesium in water is 150mg/L.

3.9. Sodium and Potassium

There is no guideline proposed for potassium ion but the concentration of sodium is ranges from 86 to 180 mg/L. S-9 and S-6 are found in maximum and minimum concentration respectively Also, the concentration of sodium in ground water influences more in agricultural activity.

3.10. Iron

Iron is the essential element for the organism. it occurs naturally in the environment as its ore like hematite. It acts as the central metal atom in the hemoglobin and transport the oxygen in the blood through organs. The deficiency of iron create anemia. The prescribed limit of iron content in drinking water is 0.30 mg/L by WHO. In the present study area, the maximum value is 0.26 and minimum value is 0.01.The iron content of the entire sample found Below Detection Limit (BDL).

3.11. Manganese

Manganese is the most abundant metals recover from earth crust in the form of oxides and hydroxides. It behaves as trace element and toxic metal due to the industrial activity, soil erosion, volcanic eruption, and human activity which increase the contaminant in ground water which change the odor and taste of the water also deposit within the pipes may break or form black precipitate. The allowable limit of manganese in ground water is 0.4 mg/L but in the present study area the maximum value is 0.08 and minimum value is 0. The manganese content of the entire sample found Below Detection Limit. All the samples found below permissible limit.

3.12. Chromium

Chromium is one of the most abundant heavy metal in nature it occur in the combined state but it exist as trivalent as well as hexavalent in nature as trace. It acts as removal of glucose from blood. But hexavalent chromium causes allergic reaction on human. Tannin and paint industry discharge most of the chromium in ground. WHO has prescribed 0.05mg/L as prescribed limit. Present study all the samples found Below Detection Limit (BDL).

3.13. Lead

Lead is a toxic heavy metal which is present in the natural environment but due to the human and industrial activity the concentration of lead increases day by day. It passes to environment through the vehicular exhaust and may causes serious health problem to child hood below six years. It also causes blood pressure, kidney damage [18]. In this study all the samples are found below the detection level.

3.14. Copper

Copper is one of the common heavy metal found in environment. It enters into groundwater through agricultural wastes, pesticides; industrial waste and it create corrosion on pipes. it is the essential element for human health but high concentration copper in drinking water give liver and kidney damage. The acceptable limit of copper in ground water is 2 mg/L as prescribed by WHO. In the present study area the maximum value is 0.04 and minimum value is 0.01. The copper content of the entire sample found Below Detection Limit (BDL).

3.15. Zinc

Zinc is an essential trace element. It enters into water on location ore are found. Lack of zinc in drinking water results slow growth and diarrhea in children, wounds not heal fastly, suppress the immune system with treating the cold and infection in ear, also preventing low respiratory infections. It may be found in excess due to industrial activity, galvanic industry, and battery production industry. From this is observed to avoid larger quantities of nitrogenous and phosphate fertilizer in agricultural lands. This creates the awareness towards excess use of pesticide [19]. The adverse effect of zinc toxicity is stomach aches; vomiting, fever and diarrhea. All of the samples in this investigation were found to be under the WHO's permitted level of 3 mg/L.

3.16. Cadmium

Cadmium is the commonly found metal in the world as ores of carbonate, sulphide and zinc. It naturally occurs in environment from the fertilizer, polluted ground water and sewage sludge, mining and effluents from industry. Anemia, bronchitis are the adverse effect shown when cadmium concentration higher than the permissible limit. WHO has prescribed 0.003mg/L as the permissible limit. In the current study sample are found below Detection Level (BDL).

4. Statistical Studies Correlation Studies

Correlation coefficient is the mutual relationship between the two factors. The direct correlation exists when increase in the value of one parameter is associated with other parameter. The positive correlation observed only when increase in one parameter causes the increase in the other parameter vice versa" [20]. The correlated coefficients between varieties of water quality parameters are measured using the Table 4. The correlation co-efficient 'r' was calculated using the equation

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{\left[n\Sigma x^2 - (\Sigma x)^2\right]\left[n\Sigma y^2 - (\Sigma y)^2\right]}} \quad (1)$$

The value of the correlation coefficient (r) ranges between +1 and -1. If the value ranges from +0.8 to 1.0 and -0.8 to -1.0 has characteristic the parameter is strongly, the value +0.5 to 0.8 and -0.5 to -0.8 has the characteristic the parameter is moderately and the value ranges from +0.00 to 0.5 and -0.00 to -0.5.(13) as the characteristic the parameter is weakly. The strong positive correlation of TDS (0.537), (0.57) with chloride and sulphite. Weak correlation of TDS (0.24), (0.467), (0.0078) and (0.044) with calcium, phosphate, Nitrate and pH.

The Correlation coefficient of EC with calcium, potassium, Bicarbonate, phosphate, Nitrate. pH is weakly correlated with sulphate (0.45). The Correlation coefficient of nitrate is positively correlated with calcium, potassium (0.41) and phosphate. Phosphate is weakly correlated with chloride (0.481).Bicarbonate and sulphates are positively correlated with sodium. Potassium (0.131) and magnesium (0.106) are strongly correlated with calcium. From the result most of the ion positively correlated with NO_3^-. This may be due to increase in agriculture activity, animal, human and poor drainage waste.

5. Conclusion

Groundwater in and around Nagapattinam, Nagapattinam district, is firm, fresh, and alkaline in character, according to physicochemical investigations. The parameters like, Magnesium, Sodium, phosphate, sulphate, Potassium, Electrical conductivity, Nitrate, Total dissolved solids (TDS), and chloride results within the allowable limit. Water chemistry signifies that higher EC and TDS shown in nearby costal region prescribe saline water traces. Almost most of the parameters showed higher values like Calcium, pH, total hardness. Higher values of Total hardness and pH indicate saline water intrusion in the particular area. S1, S3, S9 and S10 location requires some treatment for minimization of those parameters. It may be due to increase in prominent people habits and the pollutants may leach inside the ground water. The majority of parameters were reported less than the allowable limit. The low concentration of ions in the sample does not give any adverse effect for utilize the water for house hold and drinking purposes. Except S1, S3, S9 and S10 all other sample in the present region suitable for drinking purposes. Trace metal contamination in the present study area showed that S1 to S10 below the permissible limit. Statistical Application carried out by using the correlation analysis indicates that EC, Dissolved Solids, Calcium, Magnesium, Sodium, Potassium, Chlorine, Nitrate and Phosphate are the dominant ions in the study area due to the leaching of fertilizer impact [21]. The physicochemical parameters found in the entire study indicate that the quality of ground water differs from bore well to bore well. Any parameter with a higher value in a borehole indicates that the water is unfit to drink [22].Therefore, the public is advised that the groundwater source in the study area should be monitored before it is used for domestic and drinking water purposes and that the government should adopt some treatment technology in the current study region to minimize the hardness and salinity for provide safe water to the public

References

[1] G. Selvarajan, S .Punitha, "Estimation of physico-chemical parameters of ground water in Kilvelur Taluk, Nagapattinam District, Tamilnadu, India", Int. Res J Environmental Sci. **7** (2018) 37.

[2] A. Abdul Jameel, J. Sirajudeen. R. Abdul Vahith, "Studies on heavy metal pollution of ground water sources between Tamilnadu and Pondicherry, India", Advances in Applied Science Research **3** (2012) 424.

[3] C. Ramakrishnaiah, G. Sadashivaiah, "Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India", E-Journal of Chemistry **6** (2009) 523.

[4] K. Palanisami, National Agricultural Development Programme (Nadp), District Agriculture Plan Thanjavur District, Coimbatore, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, (2008).

[5] Standard methods for examination of water and waste water (19th edn.) American Public Health Association, Washington, DC, (1995).

[6] S. G. Sridhar, D. M. Balasubramaniam, S. Jenefer, P. Shanmugapriya, "Assessment of Groundwater Quality in Different Parts of Thiruvallur District of Tamil Nadu, Southern India,", J Acamedia and Industrial Research **5** (2017) 161.

[7] H. Murhekar Gopalkrushn, "Determination of Physico-Chemical parameters of Surface Water Samples in and around Akot City, Maharastra, India", Int J Res Chem Environ **1** (2011) 183.

[8] J. Vincent, "Physico Chemical Analysis Of Ground Water Near Municipal Solid Waste Dumping Sites In Arumuganeri, Thoothukudi District, Tamilnadu, India", Green Chem & Tech Letters, (2016).

[9] A. Geetha, P.N. Palanisamy, P. Sivakumar, P. Ganesh Kumar, M. Sujatha, "Assessment of underground water contamination and effect of textile effluents on Noyyal river basin in and around Tiruppur town, Tamilnadu", E J Chem **5** (2008) 696.

[10] S. Jacob Vincent., Green Chem. Tech. Lett. **2** (2016) 35. https://doi.10.18510/gctl.2015.217.

[11] D. Catroll, *Rain water as a chemical agent of geological process- a review*, USGS Water Supply **1533** (1962) 18.

[12] R. A. Freeze, J.A. Cherry, "Groundwater. Prentice-Hall Inc., Englewood Cliffs", New Jersey, (1979).

[13] D. Kannan, N. Mani, "Physicochemical analysis of groundwater from various parts of Nagapattinam District, Tamilnadu India", Int. J. of Pharma Sciences and Research **9** (2018) 51.

[14] A. K. Singh, GC. Mondal, S. Kumar, T.B. Singh, B.K. Tewary, A. Sinha, "Major ion chemistry, weathering processes and water quality assessment in upper catchment of Damodar river basin, India", Environ Geol. **54** (2008) 745.

[15] B. O. Zhang, M. Hong, Y. Zhao, X. Lin, X. Zhang, J. Don, "Distribution and risk assessment of fluoride in drinking water in the west plain region of Jilin Province, China", Environ Geo chem Health **25** (2003) 421.

[16] C. N. Sawyer, P.L McCarty, "Chemistry for sanitary engineers", 2nd ed., McGraw- hill, New York, (1967).

[17] A. Jinwal, Savita Dixit, Suman Malik, "Some Trace Elements Investigation in Ground Water of Bhopal and sehore District in Madhya Pradesh, India", J. Appl. Sci. Environ. Manage. **13** (2009) 47.

[18] J. Briffa, E. sinagra, R. Blundell, Heavy metal pollution in the environment and their toxicological effects on humans, Heliyon **6** (2020) 9. https://doi.org/10.1016/j.heliyon.2020.e04691

[19] S. Bhagavathi Perumal, P. Thamarai, "Ground water quality after Tsunami in coastal area of Kanyakumari, South Tamil Nadu, India", Int J Environ Sci **2** (2007) 99.

[20] S. Siddha, Paulami Sahu, "Assessment of groundwater potential of Gandhinagar region, Gujarat", J. Geological Society **1** (2018) 91. https://doi.org/10.1007/s12594-018-0824-y

[21] K. O. Sodeinde, "Waste Glass : An Excellent Adsorbent for crystal violet dye ,Pb2+,and Cd2+ heavy metals ion decontamination from waste water", J.Nigerian Society of Physical Sciences **3** (2021) 261,https://doi.org/10.46481/jnsps.2021.261

[22] S. P. Lakshmi, "Pollution status of ground water resources through hydrochemical characteristics - A case study from southern india", J. Nigerian Society of Physical Sciences **4** (2022) 751, https://doi.org/10.46481/jnsps.2022.751