Spatial Analysis of Groundwater Quality for Chinnar Sub Basin, Perambalur District, Tamilnadu Using GIS

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Abstract-Groundwater is one of the most important natural resources. Groundwater has become a necessary resource over the past decades due to the increase in its usage for drinking, water supply, irrigation and industrial uses etc. Groundwater resources are now facing threats due to anthroprogenic activities. Mapping of spatial variability of groundwater quality is of vital importance and it is particularly significant where groundwater is the primary source of potable water. The present study has been undertaken to analyze the spatial variability of groundwater quality for Chinnar sub basin, Perambalur and Ariyalur District, Tamilnadu state. The study area was selected based on the Hydro geological properties. A Study on Physico-Chemical parameters of water quality in the salinity affected areas of Nagapattinam District is taken up to evaluate its suitability for drinking and irrigation purposes. Ground water samples are to be collected from the study area from Veppanthattai Taluk to Sannacinallur in Ariyalur district. The water samples collected at 65 villages and analyzed for pH, Sodium, Total Hardness, TDS, Chloride, magnesium, Calcium, Sulphates, Bicarbonates, potassium, Dissolved Oxygen. Geographic Information System (GIS) is used for spatial and temporal mapping of water quality in the study area. Geographical Information System (GIS) is used for the spatial analysis and it is a powerful tool for the representation and analysis of spatial information related to water resources.

Keywords— GIS, Groundwater, Spatial variability, Physico-chemical, Chinnar sub basin and Perambalur

1. Introduction

Water is a prime natural resource, a basic human need and a precious national asset and one of the most stable compounds as well as universal solvent. Besides drinking purpose, it is

required for other human activities like cooking, bathing, washing, agriculture, industry, recreation, navigation, fisheries etc. Rapid growth of population, expansion of irrigation and increasing trend of industrialization have contributed towards rising demand for groundwater in many areas (Bhattacharya et.al.,,2005). Geochemical processes in groundwater involve the interaction of rocks with water, leading to higher concentration of chemical elements in water (Tiwari, 1985). The principles governing the chemical characteristic of groundwater were well documented in many parts of the world. The main objective of this study is to evaluate the Physico-Chemical characterization of water quality in Chinnar sub basin and its variability over space using GIS spatial mapping. This study could be used to recommend suitable management strategies for sustainable development of quality of water, Irrigation fields and water resources in the study area.

2. **Study Area**:

Thy study area Chinnar is a river which originates in the Nagoor Hills and runs through the districts of Trichirappalli and Perambalur in southern part of Tamilnadu state in India. The Chinnar sub-basin, have been selected for the present investigation. The study area falls in toposheets 58 M/3,58 M/4,58 I/11,58 I/12,58 I/15,58 I/16 covering an area of 1790.170Sq km (Fig. 1). Chinnar sub-basin is one of the major tributaries of Vellar River, India. The total length of the river is about 150 kilometers (93 mi). The river basin is in the southern part of Tamil Nadu State in South India, between the latitudes 11° 19'N - 11 9' N and longitude 78° 39'E - 79° 10’ 30” E. The basin area starts from Veppanthatai taluk Perambalur District and ends at Sivaramapuram of Ariyalur district in Tamil Nadu State .This river contains two major tributaries which are named as Elumur Odai and Koneri Odai. The terrain lies in Pachai hills, Thuraiyur Taluk of Trichirapalli District.

3. **Methodology**

The water samples were collected from 65 sample points and tested for physico-chemical parameters are compared with the permissible. The major parameters namely pH, Electrical Conductivity (EC), Total Dissolved Solids, Total hardness, Sulphates, Chlorides, Bicarbonates, Magnesium, Potassium and Calcium of the samples were analyzed (APHA,2005). The base map of the Perambalur and Cuddalore district is derived from the thematic map collected from Survey of India toposheets on 1:50,000 scale. The base map was Geo referenced; digitized and spatial

analysed by using Arc Gis9.3 Spatial interpolation technique through Inverse Distance Weighted (IDW) approach has been used in the present study to delineate the distribution of water chemistry.

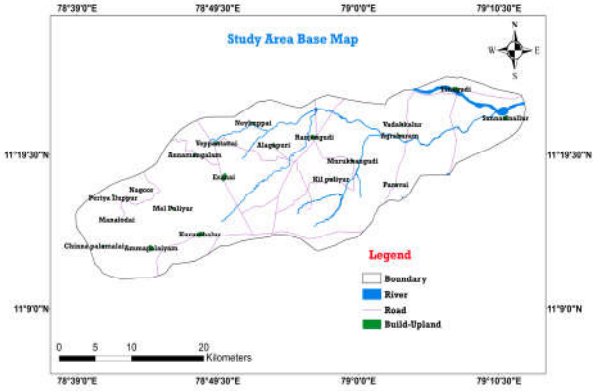

Figure 1. Study Area Map

4. Results and Discussion

The ground water sample test results of the study area, samples were summarized in Table 1.

4.1 Parameter , pH

pH is one of the important parameters of water and determines the acidic and alkaline nature of water. The pH value of water ranged between 6.7 to 8. The pH of the samples is within the prescribed standards for drinking water (WHO, 2003). The spatial variation map for pH was prepared and presented in

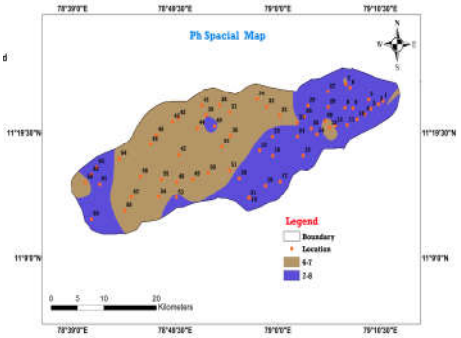

Figure 2.pH Variation map in study area

4.2 Electrical Conductivity (EC)

The Electrical Conductivity (EC) was classified into ranges from (284.8mhos/cm to 5150 mhos/cm). The spatial variation map for Electrical Conductivity (EC) was prepared and presented in Fig 3. From the map it has been observed that very small portion of the study area, the EC value is within 2250 mhos/cm, and the remaining area falls under the poor range (>3000 mhos/cm) and constitutes a major part of the study area.

Table.1 Physico-chemical parameters in post monsoon season January 2014 in Chinnar sub basin

AMPLE Id	LOCATION NAME	PH	TDS (ppm)	EC (µs/cm)	HCO_3	Ca	Mg	Cl	Na	K	SO_4	PO_4	NO_3	F	H_2SiO_4
1	Sannasinallur	8	1880	3640	1122.4	123	96	709	352	77	4.6	0.1	0.06	0.0039	10
2	Sivaramapudur	8	680	1264	671	68	54	265.9	164	11	1.4	0.045	0.011	0.207	9
3	Anganoor	7.8	906	1633	732	75	62	265.9	140	55	3.2	0.03	0.097	0	10
4	Velvimangalam	7.6	1320	2445	683.2	44	96	549.5	257	11	3.6	0.035	0.048	0.14	16
5	P.K.nallur	7.6	1950	3680	1244.4	156	89	691.3	402	21	3.4	0.1	0.035	1.75	10
6	Vathishtapuram	7.9	950	1704	878.4	130	61	336.8	206	13	1.9	0.035	0.033	0.618	6
7	Agaramsigur	7.3	2470	5150	1330	210	65	1116.7	687	31	4.6	0.055	0.17	0.364	12
8	Vayalur	7.7	2270	4530	1122.4	216	62.4	797.63	421	24	5.4	0.04	0.25	1.07	13
9	Kilaperambalur	7.8	673	1182	646.6	136	4.8	230.43	194	56	2.6	0.015	0.013	0.328	5
10	Veeramanalur	7.8	1080	2070	780.8	125	50.4	425.4	212	12	2.6	0.035	0.01	0.896	10
11	Vayalappadi	7.4	1140	2100	866.2	64	26.4	390	166	23	3	0.045	0.058	1.69	14
12	Govintharajapattinam	7.4	740	1364	768.6	135	21.6	212.7	152	15	2	0.055	0.064	0.391	13
13	Olaipadi	7.2	1210	2299	988.2	131	38.4	319.05	175	67	2	0.17	0.18	0	16
14	Veppur	7.5	1130	2157	841.8	188	50.4	425.4	174	45	2	0.055	0.2	0.759	15
15	Paravai	7.6	1030	1957	915	148	19.2	265.9	224	77	2.6	0.05	0.102	1.1	13
16	Elumur	7.8	785	1440	915	132	4.8	88.63	153	87	1.4	0.08	0.035	0.59	16
17	Asoor	7.8	1070	2021	817.4	180	24	354.5	219	109	2.6	0.05	0.098	0.569	13
18	Chittali	7.6	815	1474	719.8	152	21.6	248.15	196	21	1.9	0.04	0.06	2.33	12
19	Perali	7.5	1000	1974	707.6	108	56.4	372.22	158	42	0.6	0.035	0.1	0.928	15
20	Arumadal	7.7	890	1723	866.2	131	46	265.9	153	38	1	0.045	0.065	0.738	12
21	Sirukudal	7.8	578	1056	683.2	156	31.2	177.25	113	41	1.2	0.05	0.101	1.07	13
22	Kilapuliyur	7.6	760	1444	756.4	124	52	265.9	139	22	1.2	0.045	0.19	0.618	20
23	Murkkankudi	7.6	890	1654	866.2	44	192	301.32	164	73	5	0.115	0.14	0.207	15
24	Vaidyanatapuram	7.6	750	1415	719.8	76	21.6	265.9	256	62	0.4	0.07	0.2	0.728	17

25	Nannai	7.5	616	1114	756.4	68	16.8	159.52	211	22	0.4	0.06	0.004	0.373	14
26	Kilumattur	7.3	200	3920	1147	88	92	673.55	356	162	3	0.06	0.21	0.382	10
27	Attiyur	7.7	790	1360	841.8	40	16.8	212.7	265	56	1.8	0.06	0.027	0.4	13
28	Kudikkadu	7.6	780	1328	939.4	24	16.8	212.7	316	44	1.8	0.06	0.019	0.906	12
29	Vaddakkulur	7.7	500	745	622.2	51	4.8	106.35	176	21	1.6	0.065	0.04	0.474	8
30	V.Agaram	7.6	590	1007	744.2	64	21	124.07	191	12	1.2	0.055	0.014	0.811	7
31	kiliyur	7.3	470	820	634.4	87	31	106.35	102	17	1.2	0.07	0.01	0.464	12
32	Nallur	7.1	685	1322	732	88	28.8	212.7	207	14	1	0.07	0.1	0.588	13
33	Eraiyur sugars	6.8	1255	2413	597.8	148	62	531.75	165	21	3.4	0.065	0.07	0.418	12
34	Chinnaru	6.9	690	1232	829.6	68	24	177.25	215	22	1.2	0.095	0.01	0.769	14
35	Ranjankudikottai	6.9	1810	1613	634.4	112	45.6	301.32	200	32	1.8	0.075	0.22	0.759	14
36	Valikandapuram	6.7	2980	2638	1134.6	145	65	460.85	276	57	2	0.175	0.25	0.181	13
37	Mettupalayam	7.1	670	1248	671	91	31.2	195	142	21	1.6	0.07	0.104	0.157	13
38	Sathanvadi	6.7	1278	2455	780.8	192	36	425.4	203	44	2	0.07	0.17	0.885	15
39	Siruvayalur	7.3	862	1539	1330	116	48	159.52	267	12	1.6	0.085	0.016	1.72	12
40	Alagapuri	7.4	732	1326	671	86	21	212.7	220	52	3.6	0.015	0.027	0.608	13
41	Neykuppai	6.9	1155	2232	744.2	125	52.8	443.12	197	41	2.6	0.03	0.11	0.618	9
42	Tontapadi	7	1327	2578	1024.8	148	57.6	460.85	276	18	3	0.035	0.13	1.02	14
43	Veppanthattai	7.1	1177	2204	854	89	65	514.02	412	51	1.8	0.02	0.09	0.588	8
44	Anukoor	7.2	900	1667	951.6	121	24	248.15	243	15	1.8	0.04	0.052	2.7	14
45	Annamangalam	7.2	1050	2112	683.2	92	48	567.2	279	59	1.8	0.03	0.08	0.707	13
46	Arasalur	7.1	820	1539	902.8	160	53	319.05	174	11	1.6	0.12	0.04	0.521	12
47	Esanai	7	711	1351	610	102	41	265.9	126	13	1.8	0.025	0.2	0.991	10
48	Alampadi	7	1240	2485	927.2	89	68	567.2	315	66	1.6	0.025	0.075	1.37	12
49	Koneripalaiyam	7	1200	2316	1110.2	94	78	496.3	327	44	1.6	0.045	0.07	1.51	15
50	Elampalur	7.2	280	471	353.8	32	16.8	141.8	189	26	1.2	0.02	0.019	0.409	13
51	Sengunam	7.1	440	819	658.8	66	19.2	212.7	172	61	1.2	0.02	0.022	0.195	12
52	Vallapuram	7	765	1452	658.8	109	44	354.5	213	28	1.4	0.03	0.156	0.364	10
53	Senjeri	7.4	1360	2267	353.8	64	19.2	177.25	177	44	1.8	0.025	0.027	0.117	4
54	Kurumbalur	7.2	1440	2851	805.2	156	67	638.1	269	31	2.6	0.085	0.25	0.738	10
55	Thiruppeyar	7.2	820	1460	719.8	60	45.6	319.05	333	26	1.6	0.045	0.023	0.54	10
56	Melapuliyur	7	1420	2840	927.2	151	88	602.65	278	51	1.8	0.055	0.082	0.769	10
57	Ladapuram	7	1050	1927	1147	142	41	407.7	312	69	1	0.035	0.011	2.5	10
58	Ammapalayam	7.1	1490	2950	1012.6	77	84	691.3	481	38	3.2	0.03	0.025	0.928	12
59	Kalarampatti	7.2	1040	1959	707.6	104	16.8	354.5	247	43	1.8	0.115	0.201	0.083	15
60	Chinnapalamalai	7.8	180	331	341.6	28	4.8	88.63	111	14	1.2	0.025	0.024	0	10
61	Periyapalamalai	7.5	365	674	634.4	77	41	124.07	95	12	0.8	0.14	0.017	0.241	13

62	Manalodai	7.6	280	506	378.2	42	12	106.35	103	18	1.2	0.005	0.038	0.352	15
63	Tonur	7.7	137	284.8	256.2	32	13.9	70.9	72	27	1	0.01	0.026	0	7
64	Chinnailluppur	7.2	340	643	329.4	28	21.6	141.8	102	19	0.6	0.01	0.008	0	4
65	Nagoor	7.6	160	306	317.2	20	9.6	88.63	112	21	0.6	0.005	0.015	0.115	15
	Min	6.7	137	284.8	256.2	20	4.8	70.9	72	11	0.4	0.005	0.004	0	4
	Max	8	2980	5150	1330	216	192	1116.7	687	162	5.4	0.175	0.25	2.7	20
	Ave	7.38	969.57	1810.47	786.44	103.51	43.68	338.69	224.68	38.28	2.00	0.05	0.08	0.68	11.95

4.3 Total Dissolved Solids (TDS)

The mineral constituents dissolved in water constitute dissolved solids. The total concentration of dissolved minerals in water is a general indication of the overall suitability of water for many types of uses (Sahu, 2000). The Total Dissolved Solids (TDS) was classified into ranges (137 mg/l to2980 mg/l). The spatial variation map for TDS was prepared based on these ranges and presented in Fig 4. From the spatial variation map it was observed that part of the study area, the TDS value is in the poor range (>1000 mg/l). In the study area, the TDS value is in the medium range (500-1000 mg/l) and smaller portion of the study area has TDS under the good range (0-500 mg/l). Water contains less than 500 mg/L of dissolved solids; it is generally satisfactory for domestic use and for many industrial purposes. If the Water with more than 1000mg/L of dissolved solids usually gives a disagreeable taste or makes the water unsuitable in other respects.

4.4 Sulphates

Sulphates occur in natural waters at concentration up 50 mg/l and concentration of 1000 mg/l can be found in the water having contact with certain geological formations such as pyrite, lignite and coal (Sinha, 1994). Sulphates was classified into ranges (0.4 mg/l to5.4 mg/l) based on these ranges the spatial variation map for Sulphates has been obtained and presented in Fig 5. From the spatial variation map, it was observed that part of the study area, the Sulphates value is in the good range (0-200 mg/l).

4.5 Calcium

Calcium occurs in the water mainly due to the presence of limestone, gypsum and dolomite minerals (Kudesia, 1996). Calcium was classified into ranges (20-216 mg/l) and based on these ranges the spatial variation map for Calcium has been obtained and presented in fig. 6.

From the figure it is evident that major part of the district has a moderate range (75-200 mg/l) of Calcium.

4.6 Chloride

The presence of Chlorides in water indicates saltiness. Chloride in excess of 100mg/l imparts a salty taste (Ikhane Philips et.al. 2010). Concentrations greatly in excess of 100mg/l may cause physiological damage. It is a general fact that the presence of salts in water is related to temperature. The concentration of Chlorides in Tharangabadi Taluk depicted a range from 70.9mg/l to 1116 mg/l.

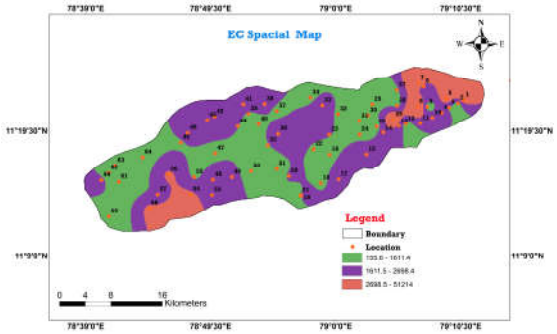

Figure 3. Ec Variation map in study area

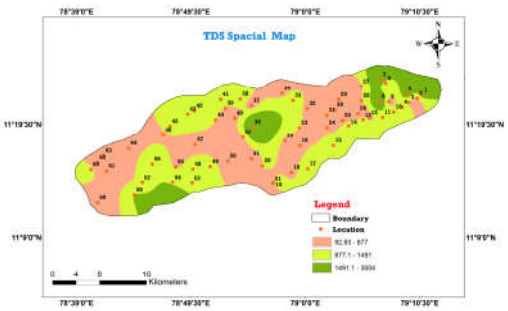

Figure 4. TDS Variation map in study area

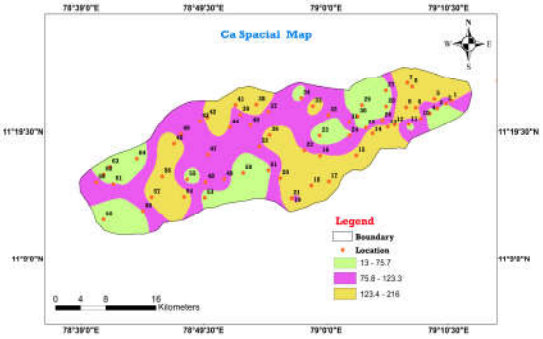

Figure 5. Sulphate Variation map in study area

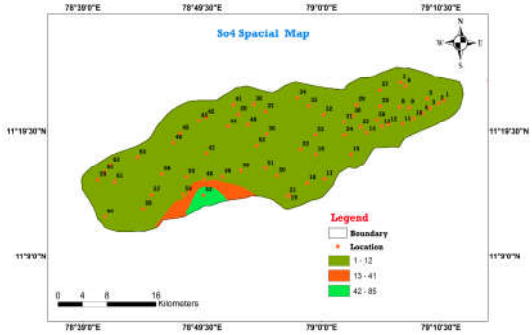

Figure 6. Ca Variation map in study area

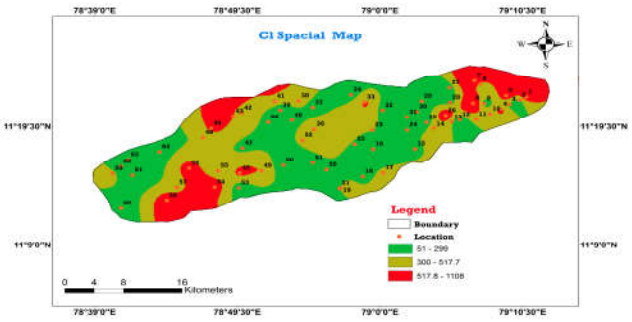

Figure 7. Cl Variation map in study area

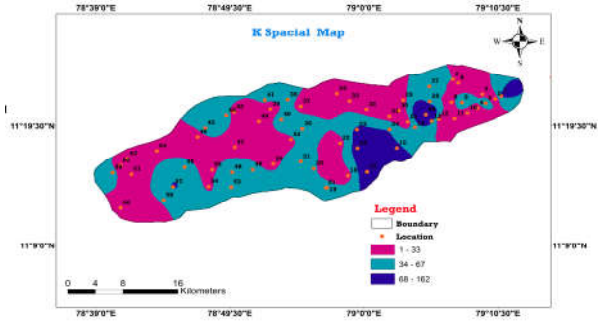

Figure 8. K Variation map in study area

Higher concentrations were once again observed in the city, region reducing in their values towards outer margins and based on these ranges the spatial variation map for Chloride has been obtained and presented in fig 7.

4.7 Potassium

Potassium levels in groundwater ranged from 11mg/L to 162 mg/l. Out of 65 groundwater samples analyzed, the concentration levels in many areas exceeded the desirable limit and based on these ranges the spatial variation map for potassium has been obtained and presented in fig 8.

4.8 Magnesium

Magnesium levels in groundwater ranged from 4.8 mg/L to 192 mg/l. The present study area there are 65 groundwater samples were analyzed and based on these ranges the spatial variation map for magnesium has been obtained and presented in fig 9.

4.9 Sodium

In the study area, sodium content in the water samples ranged from 72 mg/l to 687 mg/l respectively. The spatial distribution of sodium in the study area shown in fig.10.

4.10 Bicarbonates

In the study area, bicarbonate content in the water samples ranged from 146 mg/l to 1085 mg/l respectively. The spatial distribution of bicarbonates in the study area shown in fig. 11.

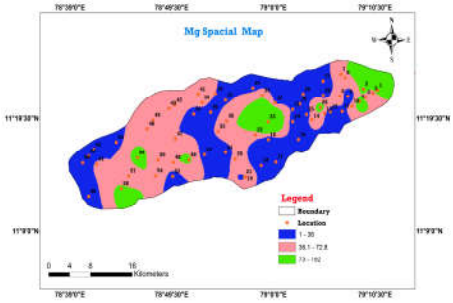

Figure 9. K Variation map in study area

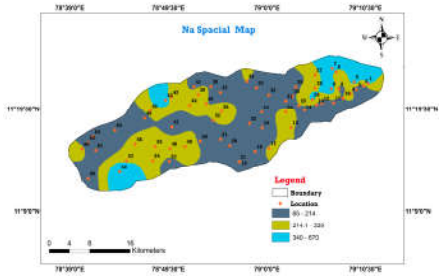

Figure 10. Na Variation map in study area

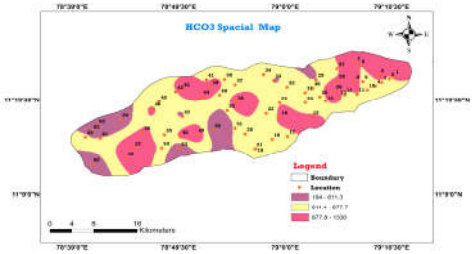

Figure 11. HCO_3 Variation map in study area

5. Conclusions

Water is an indispensable natural resource on earth. Groundwater is the major source of drinking water in both urban and rural areas. Increasing population and its necessities have lead to the deterioration of surface and subsurface water. Groundwater quality depends on the quality of re-charged water, atmospheric precipitation and inland surface water. The groundwater quality is equally important as that of quantity. Assessing and monitoring the quality of groundwater is therefore, important to ensure sustainable safe use of these resources for the various purposes. The present study has been undertaken to analyze the spatial variation of major groundwater quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids, Sodium, Sulphates, Chloride, Potassium, Magnesium and Calcium using GIS approach. GIS can provide an appropriate platform for convergent analysis of large volume of multi-disciplinary data and decision making for groundwater based studies can be done effectively. The groundwater quality in Chinnar sub basin, Perambalur district, Tamil Nadu was selected for the present study.

The spatial variation maps of major groundwater quality parameters were prepared. This study demonstrates that the use of GIS could pro-vide useful information for groundwater quality assessment. The results obtained gave the necessity of making the public, local administrator and the government to be aware of the crisis of poor groundwater quality prevailing in the area. The study helps us to understand the quality of the water as well as to develop suitable management practices to protect the groundwater resources.

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