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Hydrogeochemical Evolution Of Ground Water System In Niali And Kantapada Block

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Due to a paucity of data and efficient statistical methodologies to characterise complex natural processes and anthropogenic activities, it is difficult to understand spatial and temporal patterns of groundwater geochemistry at the regional scale over a long period of time. This study employs hierarchical cluster analysis to investigate the clustering behaviour of groundwater quality parameters. The study utilises a comprehensive dataset comprising groundwater samples collected from different locations of Niali and Kantapada block. It helps to know about the Genesis and distribution of ground water flow in a geological formation. The groundwater quality parameters considered in the analysis include chemical constituents such as pH, electrical conductivity and major ions. From pipers trilinear diagram it is revealed that the dominant hydrochemical facies of Niali and Kantapada are Ca - Mg - CI - SO4 (I) followed by Ca - Mg - HCO3 (IV). Which simply mean alkaline earth dominating alkalis and strong acid dominating weak acids. These parameters are indicative of water quality and can provide insights into the potential contamination sources and hydrogeochemical processes governing the groundwater system. Groundwater plays a crucial role in sustaining ecosystems and fulfilling human water needs. Understanding the spatial variability and clustering patterns of groundwater quality parameters is essential for effective water resource management and environmental planning. Hence the changes in groundwater geochemistry in the study area may be a short- or long-term disintegration or decomposition process of rock and/or anthropogenic activities. We also noticed indirect ion exchange reaction between host rock and water along flow system.

Keywords: Geochemistry, Hydrogeochemical facies, Chloro alkaline Index (CAI), Cluster analysis, Dendogram.

Introduction:

Geological material's adsorption and dissolution regulate the hydrochemistry of natural water. The ways through which the minerals can enter the groundwater include sorption, advection, dispersion, physical filtering, precipitation, and biological change. From the surface, the ions mainly migrate vertically downward through the unsaturated zone, while the solute experiences some limited horizontal displacement. Together with the water, the solutes enter the unsaturated zone, where they tend to spread out due to the dead end effect or dispersion. The solute may need a long period to percolate through the aeration zone. The ions typically spread out laterally and travel in the direction of ground water flow once they have reached the saturated zone.

Hierarchical cluster analysis is applied to the dataset to identify natural groupings and similarities among the groundwater samples based on their water quality characteristics. The analysis employs agglomerative clustering techniques, which iteratively merge samples into clusters based on their similarity, resulting in a hierarchical dendrogram. Various clustering algorithms and distance metrics are explored to determine the optimal clustering solution that best represents the underlying groundwater quality patterns.

The study area (Fig.1) comprises two blocks namely Kantapada in the north and Niali in the south extending between 20°0’N to 20°24’N latitudes and 85°55’30’’E And 86°13’ 30’’E longitudes, covered under survey of India toposheet number F45U3, F45U4, F45T15 & F45T16. As per CWGB 2013 the tertiary sediments encountered in the bore holes of different depths varying from 30m below ground level to 50 m below ground level in the shallow tube well in eastern sector extend beyond 150m depth of middle deep tube well.

Issues pertaining to the quality of the ground water are not now a major concern in the Niali and Kantapada block. However, the current difficulties with its quality are geogenic and to some extent anthropogenic in the form of uncontrolled village sewage disposal in open water bodies that results in the poisoning of shallow aquifers. The goal of the current study is to infer how shallow aquifer ground water's geochemistry has changed through time. The extensive chemical data have been organised and attempted to be interpreted using multivariate statistical techniques and HCA. Cluster analysis is a practical technique for locating homogeneous collections of things, or clusters. A particular cluster of objects (variables) has several traits in common. The goal of cluster analysis is to arrange wells into clusters based on how closely their variables are related to one another. After the data has been appropriately normalised, the Euclidean distance (or straight-line distance) approach is employed in this study to analyse ratio-scaled or interval-scaled data. As a result, all variables have been equally weighted and the data have undergone a log transformation by being transformed from measured variables to log-ratio. For the examination of ionic distribution, several regularly used graphical approaches and multivariate statistical techniques, including Gibbs diagrams, Piper diagrams, and scatter plots, were used in addition to cluster analysis.

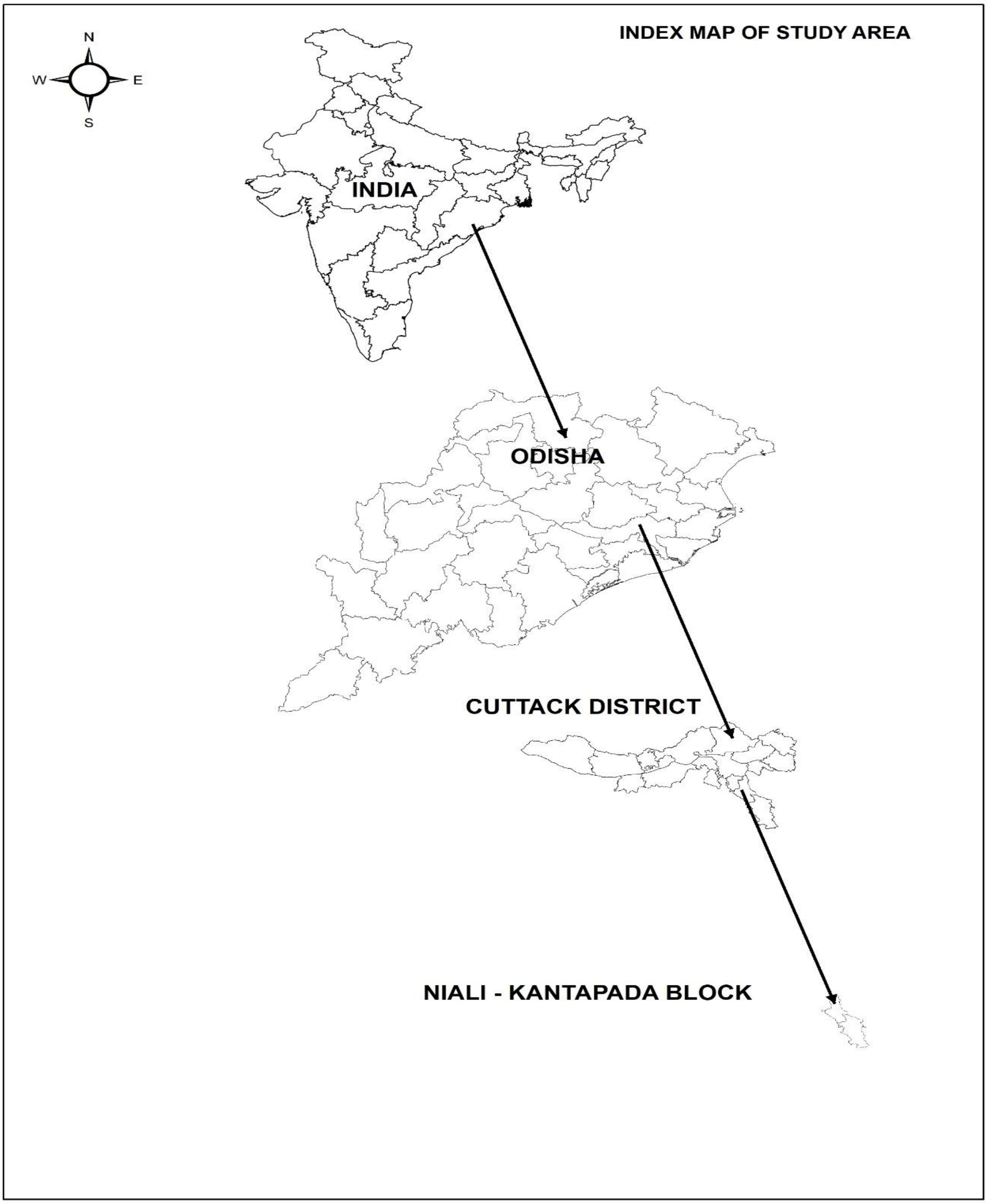

Figure 1 Location map of the study area. The outline map of India showing the district boundaries and block boundaries.

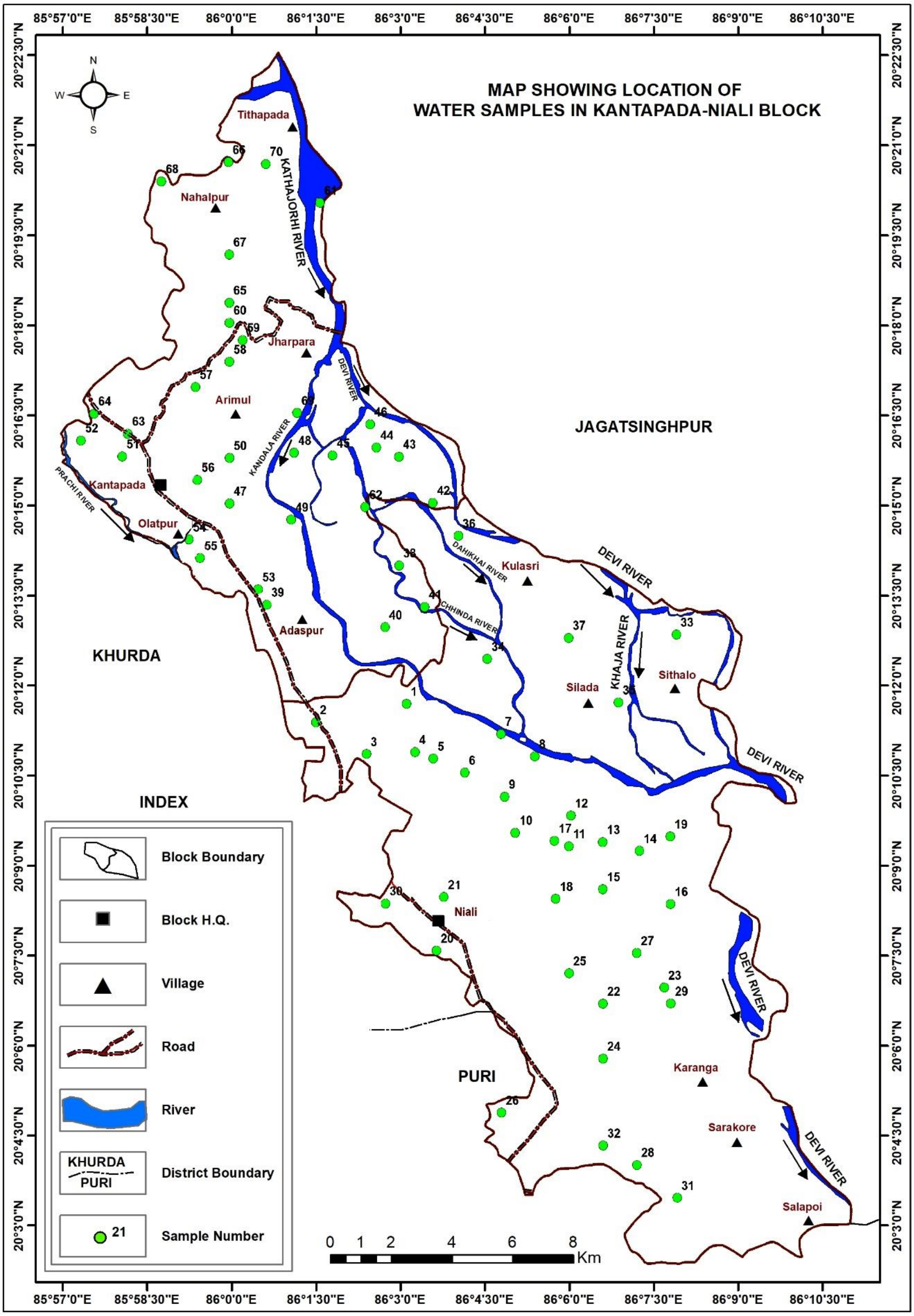

Figure:2 The map Showing sample locations. Drainage pattern of the rivers. Block head quarter, villages , road, the numbers present in the map depict the sample collection numbers

Materials and Methods

1. Hydrological data collection and their interpretation.
2. Geological study of the area with reference to lithology, geomorphology, structure and stratigraphy and preparation of geological maps.
3. Systematic collection of ground water and surface water samples and determination of their physio – chemical parameters and their interpretation and collection of well inventory data of the study area.
4. Hydrogeochemical mapping and presentation of the data in terms of map, graphs, diagrams etc.

For this investigation, seventy samples that were taken from wells and were used. For the purpose of this study, thirteen chemical variables including specific conductance (EC), pH, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Fe, HCO_3, NO^{3-}, SO_4^{2-}, Cl^{-}, F^{-}, and CO_3^{2-} were examined. The APHA standard method was used to analyse each sample [3]. Using portable metres, pH and EC were measured instantly at the sampling location. Utilising standard EDTA (ethylene diamine tetraacetic acid sodium salt), calcium and magnesium concentrations were measured titrimetrically. By titrating with silver nitrate, chloride was determined. Standard sulfuric acid was used to estimate carbonate and bicarbonate. Using spectrophotometry, nitrate, fluoride sulphate, and iron concentrations were determined. Flame photometry was used to analyse the contents of sodium and potassium. For the graphical analysis, AquaChem and Microsoft Excel 97 were also employed. Data classification was carried out by using cluster analysis (HCA).

Scope of the present work

The present work has a multidimensional scope for technical personnel in general and general public of the area in particular. The area is heavily populated and the demand for drinking water is exponentially rising with population. The present work aims to delineate potential aquifer zones to develop ground water for agriculture. Besides detailed analysis of ground water quality and quantity can help in providing solutions to drinking water problem of the area. More ever the contamination study of the ground water aims to bring to the light contaminated ground water zones and to create awareness among public about the present quality status of the ground water and upcoming threat to public health.

The result and findings of the study area can be used by the personnel engaged in water planning particularly by central and state Govt agencies and the work is likely to cater to the needs of students and scholars in the field of research in hydrological studies in other related areas.

Cluster analysis is a statistical method used to group objects or data points that are similar to each other. In the context of groundwater quality, cluster analysis can be used to group wells or sampling locations that have similar water quality characteristics. There are different methods for performing cluster analysis, including dendrogram and hierarchical classification.

Seventy number of samples were included in this study. Water samples were collected from the bore wells of the study area. The depth of the wells are varied with respect to relief of the area. The samples were tested for pH, total dissolved solids, conductivity, calcium, magnesium, chloride, sulfate and bicarbonate according to the standard methods (APHA, AWW and WPCF,1992).

TABLE NO- 1 Hydro-chemical facies of groundwater of the study area:

SL.NO.	NAME OF THE VILLAGE	Cation facies	Anion facies
1	Arapada	Na>Mg>Ca>K	HCO3>SO4>Cl>F
2	Govindarampatna	K>Na>Mg>Ca	HCO3>SO4>Cl>F
3	Anlo-II	K>Na>Mg>Ca	HCO3>SO4>Cl>F
4	Mahangapada	Mg>K>Na>Ca	HCO3>Cl>SO4>F
5	Athanga	K>Mg>Na>Ca	HCO3>SO4>Cl>F
6	Adhanga	Na>Mg>Ca>K	HCO3>SO4>Cl>F
7	Dihijang	Mg>Na>Ca>K	HCO3>SO4>Cl>F
8	Bilasuni	Mg>Na>Ca>K	HCO3>SO4>Cl>F
9	Badabankihati	Mg>K>Na>Ca	HCO3>SO4>Cl>F
SL.NO.	**NAME OF THE VILLAGE**	**Cation facies**	**Anion facies**
10	Lekhanpur	Mg>Na>Ca>K	HCO3>SO4>Cl>F
11	Bagalasahi	Mg>Na>Ca>K	HCO3>SO4>Cl>F
12	Polasara	Mg>Na>Ca>K	HCO3>SO4>Cl>F
13	Pokharigan	Na>Mg>K>Ca	HCO3>SO4>Cl>F
14	Deuli	k>Mg>Na>Ca	HCO3>SO4>Cl>F
15	Barimundei	Mg>Na>K>Ca	HCO3>Cl>SO4>F
16	Baghamara	Na>K>Mg>Ca	HCO3>SO4>Cl>F
17	Bagalgarh	K>Mg>Na>Ca	HCO3>SO4>Cl>F
18	Baharana	K>Na>Mg>Ca	HCO3>SO4>Cl>F
19	Pahanga	K>Na>Mg>Ca	HCO3>SO4>Cl>F
20	Pubakhanda	K>Mg>Na>Ca	HCO3>SO4>Cl>F
21	Niali	K>Mg>Na>Ca	HCO3>SO4>Cl>F
22	Tampada	Na>Mg>Ca>K	HCO3>SO4>Cl>F
23	Kapasi	Mg>Na>K>Ca	HCO3>Cl>SO4>F
24	Madhaba	Na>Mg>K>Ca	HCO3>SO4>Cl>F
25	Jalarpur	Mg>Na>K>Ca	HCO3>Cl>SO4>F
26	Banamalipur	Mg>Na>Ca>K	HCO3>Cl>SO4>F
27	Panimala	Mg>Na>K>Ca	HCO3>Cl>SO4>F
28	Nuasatanga	K>Mg>Na>Ca	HCO3>Cl>SO4>F
29	Korkor	K>Mg>Na>Ca	HCO3>SO4>Cl>F
30	Nuagan	K>Mg>Na>Ca	HCO3>SO4>Cl>F
31	Nachigaan	K>Mg>Na>Ca	HCO3>Cl>SO4>F
32	Nuapitapada	Mg>K>Na>Ca	HCO3>Cl>SO4>F
33	Sasanpada	Mg>K>Na>Ca	HCO3>Cl>SO4>F

34	Kasarda	K>Na>Mg>Ca	HCO3>Cl>SO4>F
35	Katikata	Mg>K>Na>Ca	HCO3>SO4>Cl>F
36	Erancha	Mg>K>Na>Ca	SO4>HCO3>Cl>F
37	Barisana	Na>Mg>Ca>K	SO4>HCO3>Cl>F
38	Uttaran	Na>Mg>Ca>K	HCO3>Cl>SO4>F
39	Adashpur	Mg>Ca>k>Na	HCO3>Cl>SO4>F
40	Noda	K>Ca>Mg>Ca	HCO3>Cl>SO4>F
41	Dimiri	Mg>Ca>Na>K	HCO3>Cl>SO4>F
42	Rahamba	Na>Mg>K>Ca	HCO3>SO4>Cl>F
43	Tunda	K>Na>Mg>Ca	HCO3>SO4>Cl>F
44	Postal	K>Na>Mg>Ca	HCO3>SO4>Cl>F
45	Brahmanabati	Mg>Ca>Na>K	SO4>HCO3>Cl>F
46	Badabil	Mg>K>Ca>Na	HCO3>Cl>SO4>F
47	Kansilo	K>Na>Mg>Ca	HCO3>SO4>Cl>F
48	Dhanamandala	Na>Mg>Ca>K	HCO3>SO4>Cl>F
49	Manikunda	K>Na>Mg>Ca	HCO3>SO4>Cl>F
50	Badakhalagan	K>Mg>Na>Ca	HCO3>SO4>Cl>F
51	Deuli	Na>Mg>Ca>K	HCO3>Cl>SO4>F
52	Chitalpur	Mg>Ca>k>Na	HCO3>SO4>Cl>F
53	Barahipur	K>Na>Mg>Ca	HCO3>SO4>Cl>F
54	Sisua	K>Mg>Na>Ca	HCO3>SO4>Cl>F
SL.NO.	**NAME OF THE VILLAGE**	**Cation facies**	**Anion facies**
55	Olatpur	K>Na>Mg>Ca	HCO3>SO4>Cl>F
56	Kantapada	Na>Mg>K>Ca	HCO3>SO4>Cl>F
57	Sanapatasundarpur	Mg>K>Na>Ca	HCO3>SO4>Cl>F
58	Badapatasundarpur	Na>Mg>K>Ca	HCO3>SO4>Cl>F
59	Chaupada	Na>Mg>K>Ca	HCO3>SO4>Cl>F
60	Jharapada	Mg>K>Na>Ca	HCO3>SO4>Cl>F
61	Gobindpur	Mg>Ca>k>Na	HCO3>SO4>Cl>F
62	Badamulei	Na>K>Mg>Ca	SO4>HCO3>Cl>F
63	Bagalpur	K>Mg>Na>Ca	HCO3>SO4>Cl>F
64	Sundargram	K>Mg>Na>Ca	SO4>HCO3>Cl>F
65	Badasailo	Na>K>Mg>Ca	HCO3>SO4>Cl>F
66	Paikapada	K>Na>Mg>Ca	HCO3>SO4>Cl>F
67	Nuagan-sasan	K>Mg>Ca>Na	SO4>HCO3>Cl>F
68	Gunadola	Mg>Na>K>Ca	HCO3>SO4>Cl>F
69	Brahamanasailo	Mg>Na>K>Ca	HCO3>SO4>Cl>F
70	Sirasundarpur	Mg>K>Na>Ca	HCO3>SO4>Cl>F

Result and discussion:

Piper (1953) introduced a tri-linear illustration which is broadly used to recognize the hydrogeochemical facies of ground water. The diagram comprises of three diverse fields. The concentration in epm of cations (Mg^+, Ca^+, Na^+, and K^+) and anions (Cl^-, SO_4^{2-}, CO_3^{2-}, HCO_3^-) are plotted in the two triangles and their overall characteristics are plotted in the diamond shaped field.

Piper (1953) trilinear diagram is made to display the relative concentration of different ions from individual water samples from the study area. The chemical reactions occurring between the minerals and groundwater is the reflectance effect of hydro chemical facies. The concentrations of most important cations

(Na^+, K^+, Ca^{2+} and Mg^{2+}) and anions (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}) in meq/l are plotted in the piper's trilinear diagram to assess the hydro geochemistry of the study area. The diamond shaped the piper diagram can be further classified into (I) Ca^{2+}-Mg^{2+}-Cl^--SO_4^{2-}, (II) Na^+- K^+-Cl^--SO_4^{2-}, (III) Na^+- K^+- HCO_3^-, and (IV) Ca^{2+}-Mg^{2+}- HCO_3^- facies. Figure- 3 and 4 display the groundwater samples categorized as several chemical categories on the piper diagram. The hydrochemical facies of the study area in Niali block is Ca-Mg-Cl-SO4 > Ca-Mg-HCO3 > Na-K-HCO3, Kantapada block is Ca-Mg-Cl-SO4 > Na-K-Cl-SO4 > Ca-Mg-HCO3 > Na-K-HCO3 Though, most Ca-Mg-Cl-SO4 and Ca-Mg-HCO_3 type of water is indicated that mixing of high salinity water. The causes of this high salinity are surface contamination. The contamination sources are irrigation return flow, domestic effluent and septic tank sewages, pollute the existing water by ion exchange reaction. But mixed water types are characterized by dissolution of Ca-Na-HCO_3 and NaCl and recharge the fresh water. However, most of the samples are clustered in field I and IV indicates alkaline earth dominating alkalis and strong acids dominating weak acids.Dominant hydrochemical facies of Niali and Kantapada are Ca – Mg – Cl - SO_4 (I) followed by Ca – Mg – HCO_3 (IV).

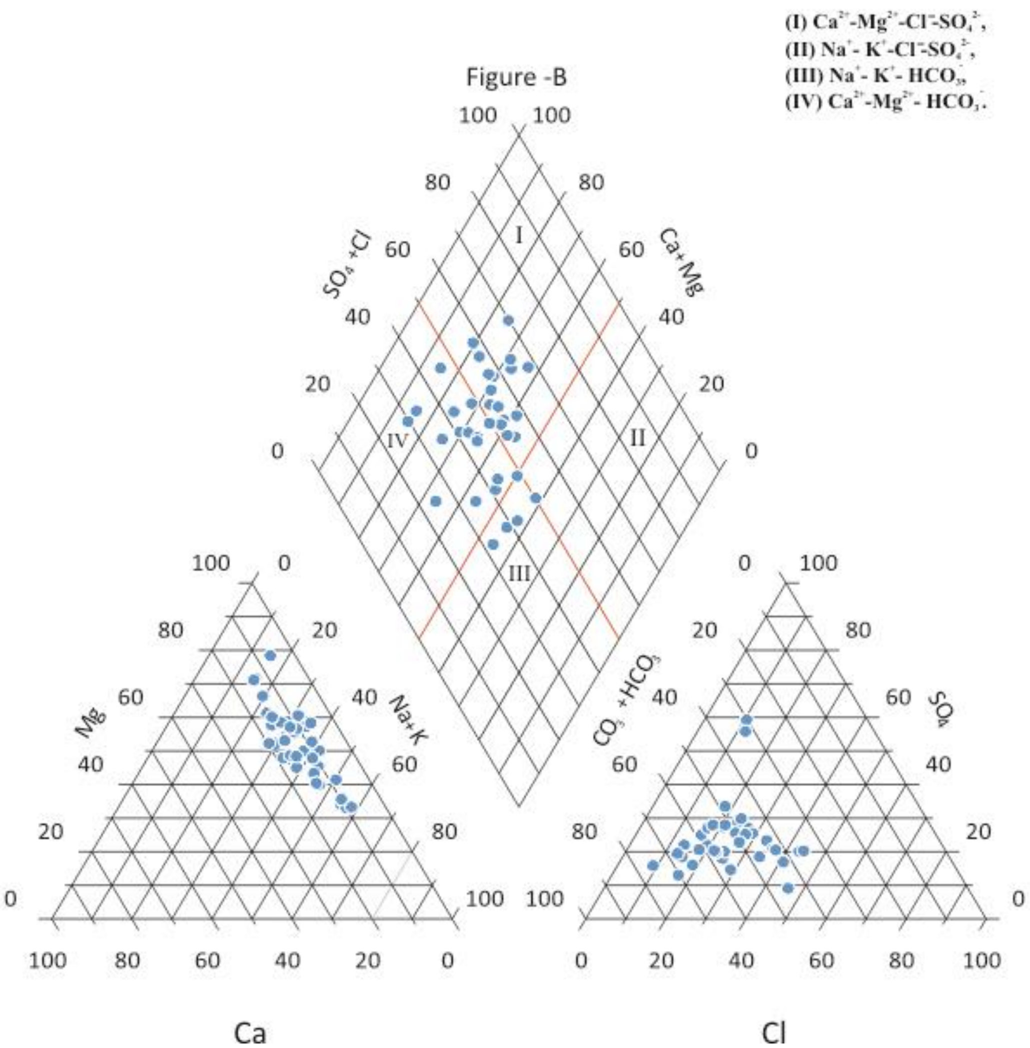

Figure – 3 Post monsoon Piper's diagram of study area (B) Niali block

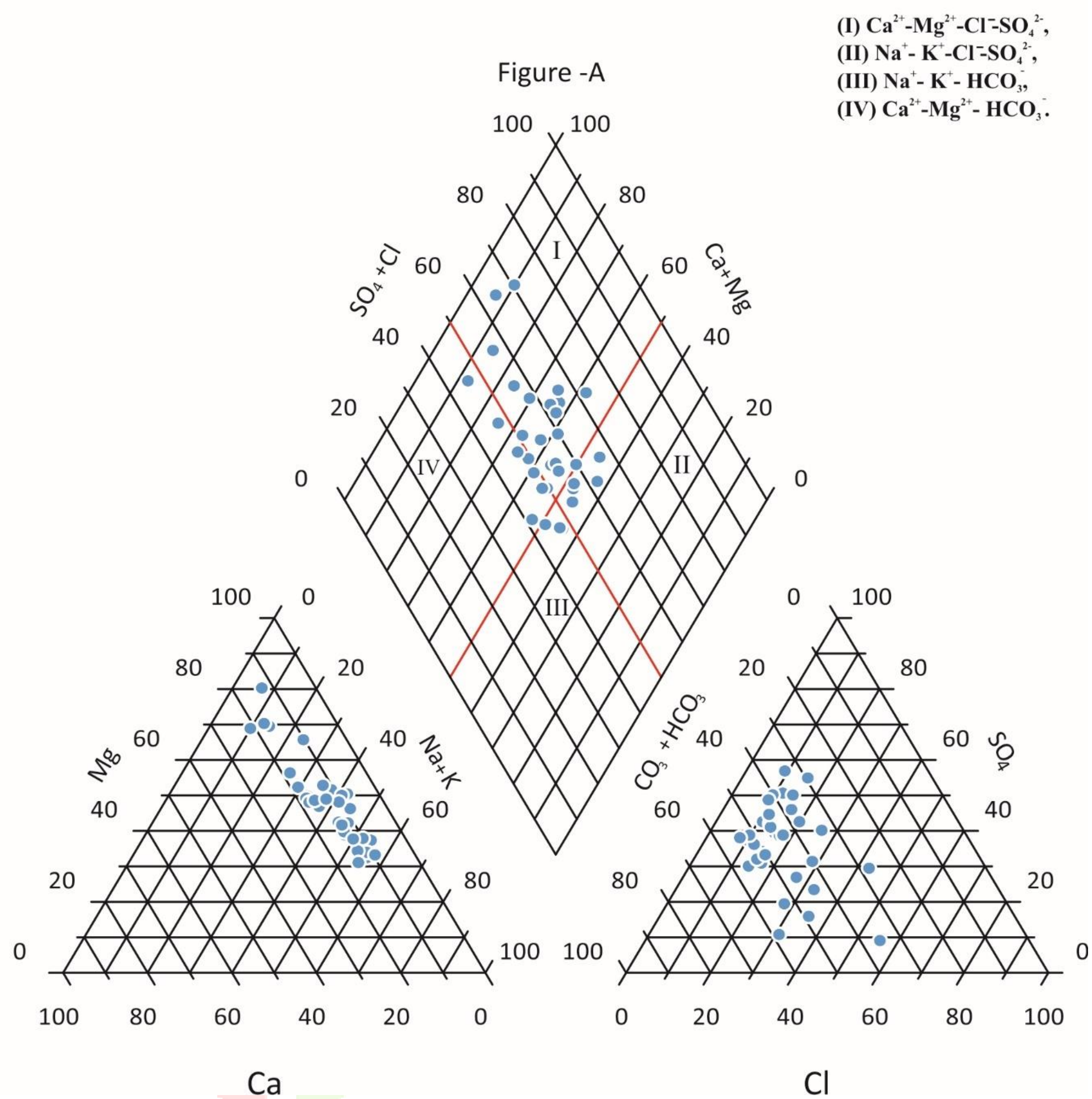

Figure – 4 Pipers diagram of post monsoon study area (A) Kantapada

Ion exchange and chloro-alkaline indices.

The ion exchange process between groundwater and the host rock, as the groundwater moves or resides can be identified by the value of chloro-alkaline indices (CAI) [32] [33]. The equation for calculating CAI is as follows:

$$CAI\text{-}1 = [Cl^- - (Na^+ + K^+)]/Cl^-$$

$$CAI\text{-}2 = [Cl^- - (Na^+ + K^+)] / (SO_4^{2-} + HCO_3^- + CO_3^{2-} + NO_3^-)$$

Both Chloro alkaline index 1 and Chloro alkaline index -2 showed negative values which is simply means there is an ion exchange between Na+ and K+ in water with Ca2+ and Mg2+ in rocks is present. Whereas a positive ratio of CAI represents there is no base exchange. If the value of Chloro alkaline index is zero no ion exchange process is favoured. In these cases, the base rocks of the water are the main sources for dissolved solids in the groundwater.

As shown in Figure 5 & 6 most groundwater samples within the study area (94%) revealed negative CAI-1 and CAI-2, and few specimens (6%) show positive values. Based on the results of this experiment, the ion exchange process predominates over the reverse ion exchange process. Particularly negative CAI values nearby indicate numerous cation-anion exchange processes. The sodium in the aquifer rocks and the calcium and magnesium in the groundwater are exchanged. Additionally, the Na+ level in the groundwater system rises as a result of this ion exchange process.

Table 2 Chloroalkaline index to classify the Groundwater samples of Niali and Kantapada block.

Sample No	CAI	CAI II
1	-1.19	-0.17
2	-5.08	-0.68
3	-3.02	-0.37
4	-1.32	-0.27
5	-3.00	-0.70
6	-0.73	-0.15
7	-2.58	-0.25
8	-1.35	-0.14
9	-3.53	-0.45
10	-1.02	-0.17
11	-0.71	-0.13
12	-2.34	-0.32
13	-3.88	-0.54
14	-5.11	-0.30
15	-0.39	-0.13
16	-1.44	-0.20
17	-2.91	-0.57
Sample No	CAI	CAI II
18	-4.44	-0.77
19	-4.25	-0.87
20	-6.50	-0.60
21	-5.01	-0.83
22	-0.15	-0.04
23	0.09	0.04
24	-3.20	-0.64
25	-1.42	-0.45
26	0.14	0.05
27	0.12	0.04
28	-0.84	-0.40
29	-2.51	-0.59
30	-2.29	-0.52
31	-0.93	-0.34
32	-0.40	-0.20

33	-0.43	-0.22
34	-0.90	-0.22
35	-1.25	-0.15
36	-1.72	-0.14
37	-2.35	-0.21
38	-0.13	-0.04
39	0.78	0.59
40	-1.42	-0.69
41	0.66	0.20
42	-1.50	-0.35
43	-6.26	-0.64
44	-5.13	-0.64
45	0.30	0.04
46	-1.35	-0.32
47	-5.45	-0.44
48	-2.18	-0.26
49	-2.67	-0.26
50	-2.65	-0.30
51	-1.42	-0.38
52	-3.00	-0.33
53	-4.24	-0.56
54	-3.05	-0.38
55	-3.13	-0.44
56	-2.98	-0.31
57	-3.34	-0.25
58	-3.04	-0.27
59	-3.99	-0.28
60	-1.90	-0.16
61	-2.76	-0.15
Sample No	**CAI**	**CAI II**
62	-6.69	-0.59
63	-1.08	-0.27
64	-3.19	-0.36
65	-1.51	-0.35
66	-7.55	-0.53
67	-5.97	-0.40
68	-4.29	-0.29
69	-2.20	-0.28
70	-0.31	-0.05

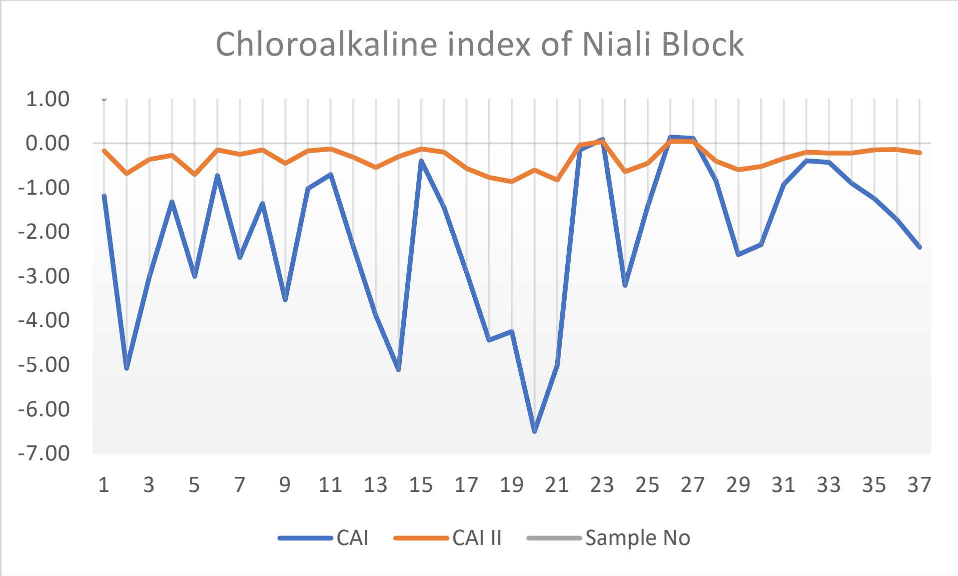

Figure 5 Chloro-alkaline index for groundwater samples of Niali Block

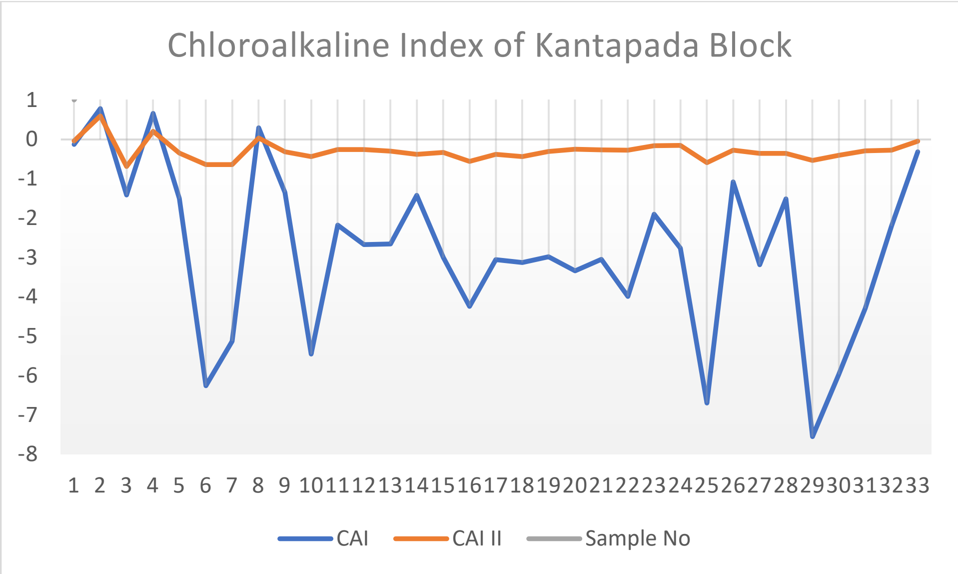

Figure 6 Chloro-alkaline index for groundwater samples of Kantapada Block

The results of the hierarchical cluster analysis reveal distinct clusters or groups of groundwater samples with similar water quality characteristics. These clusters provide valuable information about spatial patterns and potential sources of contamination or natural processes influencing groundwater quality. The identified clusters can guide decision-makers and water resource managers in implementing targeted remediation strategies, monitoring programs, and land-use planning measures to ensure sustainable groundwater management.

These observations make it clear that weathering and precipitation in the study area have caused an active process of disintegration to occur. Multivariate statistical and cluster analysis has been applied to the dissolved concentration of the constituents and environmental aspects such lithology in order to determine the precise relationship between the hydro geochemistry of water samples and their process.

Seventy number of samples were included in this study. Water samples were collected from the bore wells of the study area. The depth of the wells are varied with respect to relief of the area. The samples were tested for pH, total dissolved solids, conductivity, calcium, magnesium, chloride, sulfate and bicarbonate according to the standard methods (APHA, AWW and WPCF,1992).

The descriptive statistics of the water quality parameters are included in the statistical analyses and are reported as mean, standard deviation, and range. In order to demonstrate the connections between the measured parameters, correlation analysis was also carried out. The factor loadings were determined using factor analysis using varimax rotation on the standardised data (Kaiser, 1958; Davis, 1973). The examined wells were categorised using hierarchical cluster analysis. The Ward method, which is regarded as being effective, was used since it assesses the distances between clusters using the analysis of variance method. The sum of squares of any two clusters that can form at each phase is also minimised by the Ward approach (Ward, 1963).

Table- 3 The group statistics data of Niali and Kantapada Block

Group Statistics					
	Moonsoon Status	No. of samples	Mean	Std. Deviation	Std. Error Mean
Ph	Pre-monsoon	70	6.52143	.216221	.025843
	Post-monsoon	70	6.44486	.211761	.025310
EC_IN	Pre-monsoon	70	212.40000	94.271640	11.267616
	Post-monsoon	70	178.57143	96.212412	11.499583
TDS_IN	Pre-monsoon	70	131.48571	57.645781	6.889989
	Post-monsoon	70	114.00000	61.697955	7.374316
TA	Pre-monsoon	70	123.40000	42.265002	5.051634
	Post-monsoon	70	141.74286	41.058349	4.907411
TH	Pre-monsoon	70	93.04286	34.799399	4.159324
	Post-monsoon	70	87.65333	36.712934	4.388035
Calcium	Pre-monsoon	70	29.68571	8.510084	1.017150
	Post-monsoon	70	25.42857	10.012415	1.196712
Magnesium	Pre-monsoon	70	63.47643	29.016052	3.468082
	Post-monsoon	70	62.19886	29.434050	3.518042
Sodium	Pre-monsoon	70	59.13329	20.640559	2.467019
	Post-monsoon	70	51.54414	20.041591	2.395428
Potassium	Pre-monsoon	70	61.78157	39.049574	4.667317
	Post-monsoon	70	53.52343	37.694470	4.505351
Bicarbonate	Pre-monsoon	70	123.40000	42.265002	5.051634
	Post-monsoon	70	141.74286	41.058349	4.907411

Chlorine	Pre-monsoon	70	44.80000	20.783633	2.484119
	Post-monsoon	70	36.90000	18.554385	2.217673
Florine	Pre-monsoon	70	.27814	.061132	.007307
	Post-monsoon	70	.12034	.111340	.013308
Sulphate	Pre-monsoon	70	81.76566	43.268349	5.171557
	Post-monsoon	70	73.07857	42.516663	5.081713
Iron	Pre-monsoon	70	3.02897	2.980216	.356204
	Post-monsoon	70	2.32551	2.331728	.278695

HCA classifies the data in a fairly straightforward and direct manner, with the outcomes shown as a dendogram (Davis). The number of groups in the current study was decided upon after carefully examining the dendogram (Figure 5). The seventy wells were divided into distinct groups according to the dendogram's interpretation utilising the variables (cation and anion). In the study area sodium, fluorine and sulphate are the major cation and anion with a significance error of 1% as per the levene's test. In accordance with HCA, these ion studies show that exchange has been happening in the direction of water flows. It demonstrates that calcium type water will eventually change to sodium type water and reach a state of dynamic equilibrium along the hydraulic gradient. As the research location is known to have temperatures above 40°C and little precipitation before the monsoon, the groundwater is salt-saturated from evaporation. CaCO3, MgCO3, CaSO4, Na2CO3, Na2SO4, NaHCO3, MgSO4, MgCl, CaCl, KCl, and KNO3 are the salts that precipitate in that order. As aridity increases, salts with higher solubility typically precipitate first. The idea is that the earlier salts are enhanced in the water after being precipitated by evaporation first. The research area's waters have a noticeable high content of Na+. This is because rock weathering and precipitation are more severe in the former than the latter. Additionally, in a system with low concentrations of solution, sodium tends to remain in solution as Na+ and move along the hydraulic gradient without interacting with any mineral surface sites or precipitation reactions. Hem J D (1985) as a result of the concentration of sodium and potassium in solution along the flow channel caused by alkali metals' weaker surface adsorption with minerals as compared to divalent alkaline earth metals Plummer LN, William B (1980). The observed high concentration of sulphate and fluorine in some samples in the study area may be attributed to the oxidative weathering or resulting from local recharge and contamination from anthropogenic influences.

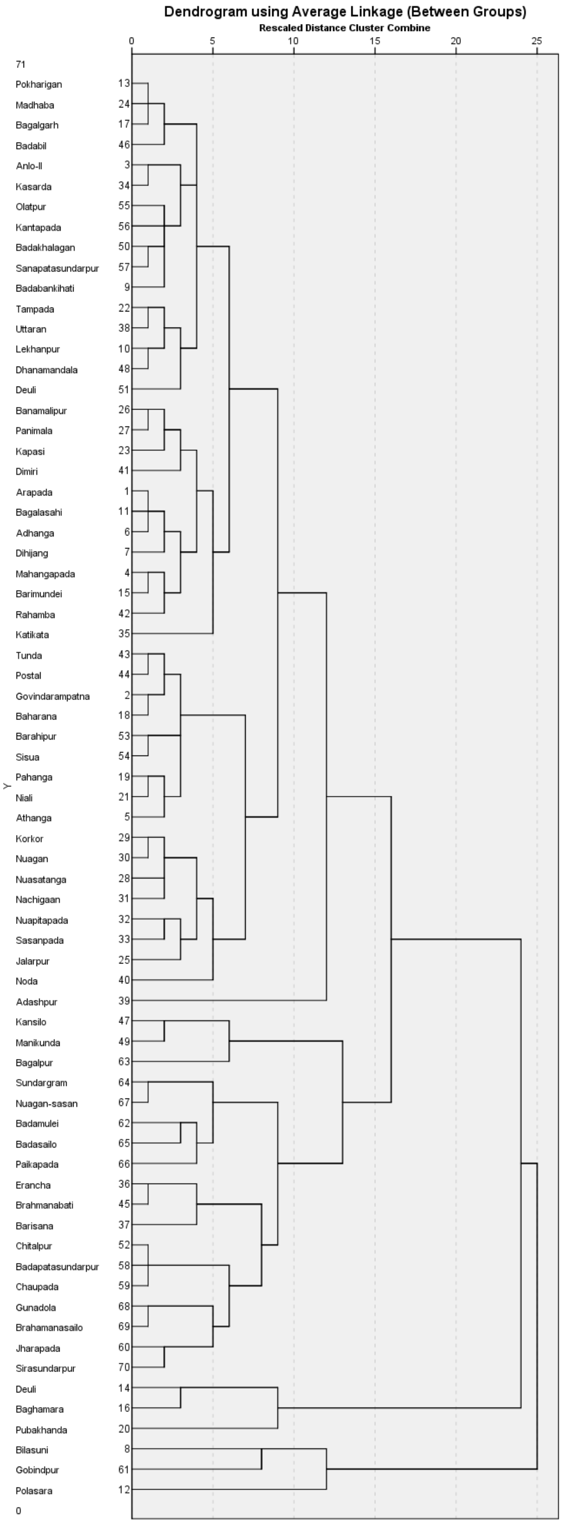

Figure 7 The dendogram showing cation and anion values of (Calcium, Magnesium, Sodium,Potassium,Bicarbonate,Chlorine,Fluorine, Sulphate, Iron) of Niali and Kantapada block.

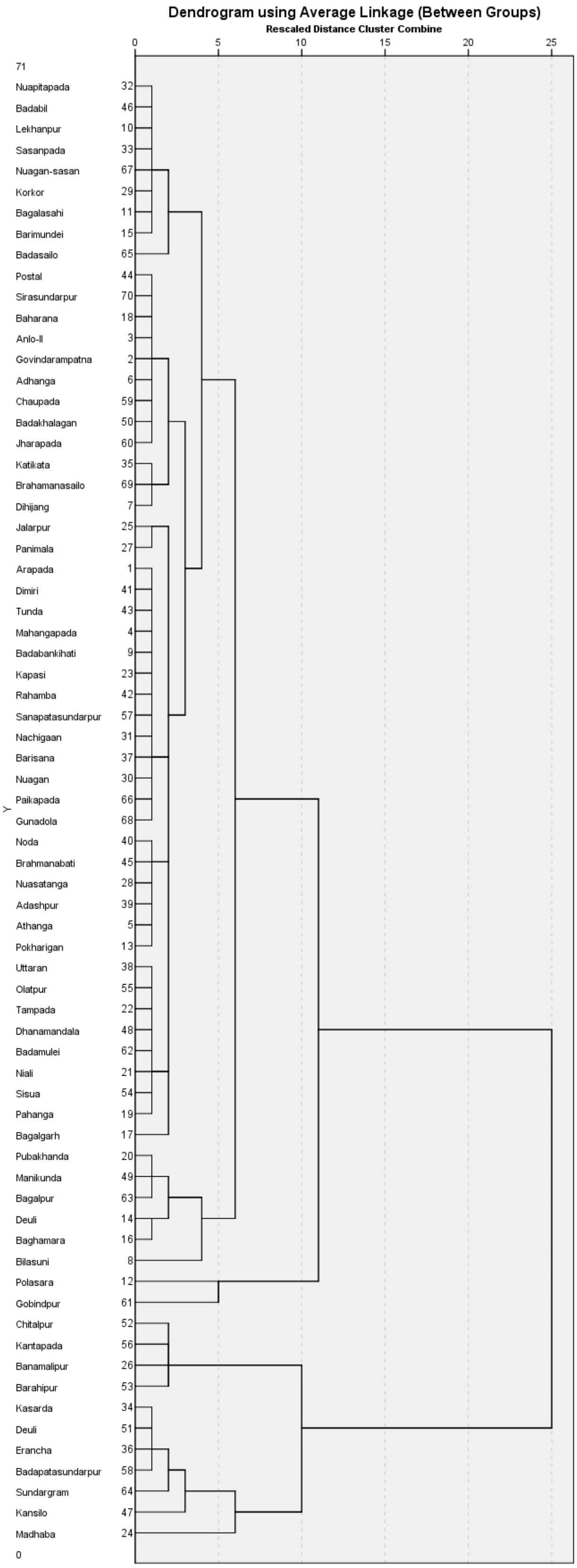

Figure 8 The dendogram showing post monsoon data of pH, EC, TDS, TA and TH values of Niali and Kantapada block.

Conclusion:

The hydrochemical facies in Niali block is Ca-Mg-Cl-SO4 > Ca-Mg-HCO3 > Na-K-HCO3, whereas Kantapada block is Ca-Mg-Cl-SO4 > Na-K-Cl-SO4 > Ca-Mg-HCO3 > Na-K-HCO3 Though, most Ca-Mg-Cl-SO4 and Ca-Mg-HCO_3 type of water is indicated that mixing of high salinity water. The causes of this high salinity are surface contamination. The contamination sources are irrigation return flow, domestic effluent and septic tank sewages, pollute the existing water by ion exchange reaction. But mixed water types are characterized by dissolution of Ca-Na-HCO_3 and NaCl and recharge the fresh water. However, most of the samples are clustered in field I and IV indicates alkaline earth dominating alkalis and strong acids dominating weak acids.

Index to base exchange values indicate that the indirect ion exchange process were taken place in the region.

These ion studies accord with HCA, showing that exchange is currently taking place along the river's course. Calcium type water will eventually transform to sodium type, and the discharge area will reach a condition of dynamic equilibrium. Since Ca2+ and HCO3- are lost through precipitation and dissolution, Na+ predominates in the solution. This is because the former exhibits greater rock weathering, precipitation, and surface adsorption than the latter. Evaporation, dissolved solids content, solubility, and hydraulic gradient all have a role in determining the hydrochemistry of ground water in the research area. The initial salt content, the length of evaporation, meteorological variables, and relative retention time all affect precipitation and salt dissolution. As aridity increases, salts with higher solubility typically precipitate first. Combining the aforementioned multivariate statistical techniques with HCA seems to provide a methodology that maximises the benefits of both approaches while minimising the drawbacks of each. In conclusion, hierarchical cluster analysis offers a powerful approach for understanding the clustering behaviour and spatial patterns of groundwater quality parameters. By revealing inherent similarities among groundwater samples, this analysis facilitates the identification of potential contamination sources and the development of appropriate management strategies. The findings of this study contribute to improved understanding and effective management of groundwater resources, thereby promoting sustainable water supply and protecting ecosystem health.

References:

[1] APHA American Public Health Association (APHA) (2005) Standard methods for the examination of the water and waste water, 1134 p.

[2] Bureau of Indian Standards (2012) Indian Standard Drinking Water - Specification (Second Revision), IS 10500:2012

[3] Piper, A.M. (1953). A graphic procedure in geochemical interpretation of water analysis, U.S. Geol. Survey. Groundwater note No. 12,63

[4] Schoeller H 1965 Qualitative evaluation of groundwater resources Methods and techniques of groundwater pp 54-83

[5] Davis J (1986) Statistics and Data Analysis in Geology. (2ndedn), Wiley, New York, USA.

[6] Schoeller H 1967 Geochemistry of groundwater—an international guide for research and practice (Paris: UNESCO)

[7] Sawyer, C. N. and Mc Carty, P. L. (1967) Chemistry for sanitary engineers, 2nd edition, McGraw Hill, New York, 518p.

[8] Todd, D. K., (1980). Groundwater Hydrology, Wiley, New York, 535p.

[9] Varol S and Davraz A 2014 Assessment of geochemistry and hydrogeochemical processes in groundwater of the Tefenni plain (Burdur/Turkey) Environ. Earth Sci. 71 4657–73

[10] World Health Organization (2004) Guideline of Drinking water quality in Health criteria and other supporting information. World health Organization, 2:336.

[11] Aneeshkumar N, AGS Reddy. Hierarchical Cluster Analysis as an Indicative of the Hydrogeochemical Evolution of Ground Water in a Shallow Aquifer System. Int J Environ Sci Nat Res. 2021; 26(5): 556197.