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Research Article

A STUDY ON HYDRO GEOCHEMISTRY OF WATERS IN UPLAND AREAS IN EAST GODAVARI REGION OF ANDHRA PRADESH BY USING FACTOR ANALYSIS

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Abstract

Ground water can be considered as the main source for domestic, agriculture and industrial uses. In the present research study, it is proposed to carry out the study of hydro chemistry to explain the hydro chemical characteristics for evaluating the quality of ground waters in upland areas near Jaggampeta in East Godavari District of Andhra Pradesh. The Physicochemical parameters viz., pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Na, K, Ca^{2+}, Mg^{2+}, F^-, Cl^-, NO_3^-, SO_4^{2-}, PO_4^{3-} were characterized for 12 ground water samples collected during pre and post monsoon seasons. In addition, factor analysis was performed which provides an insight into the source of parameters which are responsible for the water quality changes that occur in the area. The present study elucidated the effectiveness of factor analysis in evaluating the changes in ground water quality in study area which are dominated by natural and anthropogenic activities.

Keywords: Ground Water, quality, Parameter, Factor Analysis,

Introduction

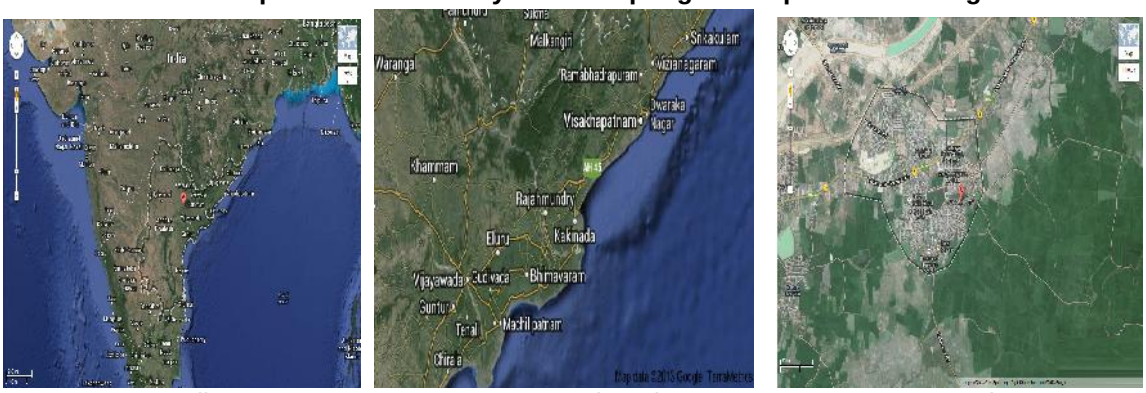
About 95% of rural population living in India depends on ground water for domestic use (Moharir, A., et al., 2002). During the past decade wide spread reports of ground water contamination have increased public concern about drinking water quality (Yanggen, D.A. and S.M. Bom 1990). The concept of water quality has been evaluated in the past owing to greater understanding of water mineralisation process and greater concern about its origin (Shane. S., Jerzy. J., 2003). The quality of water is an indicator of water – rock interaction, residence time and recharge zone conformation (Cronin. A.A., et al., 2005). The chemical composition of ground water is controlled by many factors viz., composition of perspiration, mineralogy of water shed and aquifers, climate and topography. These factors can combine to create diverse water types which change in composition spatially and temporally. Mining is also a major activity causing water pollution(Allen, S.K, et al., 1991) (Choubey, V.D. 1991). Mining affects fresh water through heavy use of water in processing ore, and through water pollution from discharge mine effluent and seepage from tailings and waste rock impoundments. Human activities such as mining threaten the water sources on which we all depend.

The limestone mining can cause hazardous environmental impacts on air, water, soil, land and vegetation. During 2007-09, extensive studies were carried out around limestone mines at Ras, Pali District by Geological survey of India (Galero, D.M., et al., 1998) and the studies were done to suggest suitable environmental protection measures to be taken through preparation of Environmental Management Plan. In Limestone or dolomite areas, any soil and water condition that generates flowing on the surface can potentially impact groundwater by moving into bedrock pathways (http://forecast.weather.gov). The water then flows through the limestone layers (0.6-1.2m thick), which adds additional alkalinity by the dissolution of calcite. The iron precipitates down gradient after contact

with the atmosphere. These systems have been found to produce alkalinity (Watzlaf GR 1995) (Watzlaf GR, et al., 2000). Keeping in view the existence of lime stone mining in the study area, it is proposed to carryout studies on characterisation of ground water and by employing the multivariate statistical methods in particular factor analysis to extract significant information from hydro chemical data set for evaluating the quality of ground water.

The study area is located in jaggampeta of East Godavari District of Andhra Pradesh between the latitudes$17^0.4^1$ N and longitude $82^0.03^1$E. Ground water samples were collected around mining activity area at distance of 0.5,1 and 2 km to each side of East, West, North, South directions and the details are presented in fig-1. The details of sampling code and locations and type of source are presented in Table-1.

The satellite picture of the study area sampling site is presented in figure-1



India East Godavari Study Area

Materials and Methods

Containers made of polythene were employed for sampling of ground water and preserved for analysis. Twelve ground water samples were collected and analyzed for physicochemical parameters which include pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Ca, Mg, Na, K, Chloride, Sulphate and Phosphate. pH determined by pH meter (Global-DPH 505, India – Model) and conductivity measured by the digital conductivity meter (Global-DCM-900-Model), TDS calibrated from the relation TDS= Electrical conductivity(EC) x0.64. Total Hardness, Total Alkalinity and Chloride were estimated by Titrimetry. Sulphate and Phosphate measured by Spectrophotometer (Vissican167, Systronics), Na and K by Flame photometry (Systronics).

12 Ground water samples from bore wells or hand pumps were collected for two season's pre and post monsoon. The collected samples were analyzed for the parameters pH, EC, TDS, Na, K, Ca^{+2}, Mg^{+2}, Cl^{-}, HCO_3^{-}, NO_3^{-}, SO_4^{-2} and PO_4^{-3} following standard procedures(APHA 1992) and the data is presented in table-1,2 and 3.

Table:-1: Sampling Code, Location, Type of Source

Sampling Code	Sampling Location	Type of Source
W-1	Radha Soami Satsang Hall(East)	BW
W-2	Opposite of Satsang (1km)	BW
W-3	Palm oil field (2km)	BW
W-4	Himalaya enclave (West)	BW
W-5	Sri Venkateswara Public School (1km)	BW
W-6	Near saw mill (2km)	BW
W-7	Hemu birds shed, Kottapeta (North)	BW
W-8	Children's learning school (1km)	BW
W-9	Social welfare school (2km)	BW
W-10	Near Main Road (South)	BW
W-11	Near Highway Bridge down (1km)	BW
W-12	Milk Dairy (2km)	BW

BW-Bore Well and OW-Open Well

Table-2: Physicochemical Characteristics of Ground Water

Sample Code	pH		EC (µmhos/cm)		TDS (mg/l)		TH (mg/l)		TA (mg/l)		Ca^{+2} (mg/l)		Mg^{+2} (mg/l)	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Post	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
W-1	6.9	7.7	497	584	318	374	400	300	300	400	120	80	24.4	24.4
W-2	7.7	7.9	921	1120	589	717	500	400	400	700	80	120	73.2	24.4
W-3	7.1	7.9	978	1160	626	742	500	500	400	700	80	80	73.2	73.2
W-4	7	7.7	411	632	263	404	500	500	300	500	120	120	48.8	48.8
W-5	7.5	8.1	516	597	330	382	600	500	300	500	160	120	48.2	48.8
W-6	7.1	7.9	912	883	584	565	500	400	400	800	40	160	97.6	24.4
W-7	7.3	8	638	818	408	523	500	500	400	700	80	80	73.2	73.2
W-8	8	7.8	666	874	426	559	400	500	400	600	80	80	48.8	73.2
W-9	7.2	7.8	1360	1740	870	1113	800	700	400	800	120	40	122	146
W-10	7.8	8.1	828	739	530	473	300	300	400	500	80	80	24.4	24.4
W-11	7.7	8.3	1210	1120	774	717	600	700	500	800	80	40	97.6	146
W-12	7.6	7.6	527	755	337	483	400	400	400	600	80	80	48.8	48.8

Table-3: Physicochemical Characteristics of Ground Water

Sample Code	Na^{+} (mg/l)		K^{+} (mg/l)		F^{-} (mg/l)		Cl^{-} (mg/l)		So_4^{-2} (mg/l)		No_3^{-} (mg/l)		Po_4^{-3} (mg/l)	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Post	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
W-1	36.3	9.3	1.6	0.5	0.4	0.6	71	35	21.3	23.8	7	8.6	3.5	4.1
W-2	81.7	17.9	3.8	0.5	0.7	0.8	142	142	23	30.8	9	12.1	4.2	4.7
W-3	95.3	17.5	2.8	0.4	0.83	0.85	248	142	29.7	27.4	11.5	13.4	4.4	4.8
W-4	26	8	6.7	1.4	0.52	0.62	35	35	22.3	23.3	5.4	8.6	3.2	4.2
W-5	36.1	9.8	3.4	0.7	0.54	0.63	106	71	23.6	12.4	8.2	12.4	4.6	5.2
W-6	42.2	7.5	82.7	14.3	0.62	0.72	71	35	37.8	27.4	9.4	15.5	3.8	4.5
W-7	50	12.7	4	0.8	0.56	0.72	71	35	21.3	121	5.6	8.4	3.6	4.2
W-8	29.4	9.2	59.5	10	0.61	0.68	71	35	23.2	25.6	4.8	6.3	5.2	5.8
W-9	108	24.1	12.3	1.1	0.86	0.96	284	142	34.6	50.7	13.4	15.6	4.8	5.3
W-10	69.3	9.6	4.4	2.6	0.63	0.78	106	35	33.9	21.7	11.3	13.7	5.2	6.4
W-11	115	19.5	2.6	0.5	0.86	0.89	142	106	32.2	29	6.8	8.9	4.8	5.7
W-12	46.5	9.9	3.9	2.8	0.65	0.75	35	71	23.5	180	6.3	9.2	3.8	4.4

Processing of Data

The analytical data were used as variable inputs for factor analysis was performed employing SPSS package described by Nie, the data were standardized according to criteria(Davis JC, 1973).This procedure renders a new rotated factor varimax (Table-4&5) in which each factor is described in terms of only those variables and affords greater ease for interpretation. Factor loading is an indicator of the degree of closeness between the variables and the factor analysis provides several positive features that allow interpretation of the data set.

By verifying the factor loadings, communalities and Eigen values the variables belonging to a specific chemical process can be identified and the significance of the major parameters can be evaluated in terms of the total data set and in terms of each factor. Communality is an indicator of the error term. The factor scores for each sample and reflect the importance of a given factor at that sample site, the factor scores can be counted for each factor and for evaluating the aerial importance of the chemical process represented by that factor. Factor scores can be related to intensity of the chemical process described by each factor (Dalton MG & Upchurch SB, 1978). Extreme negative numbers (<-1) reflect areas essentially unaffected by the process and positive scores (>+1) reflect areas most affected. Near zero scores approximate areas affected to an average degree by the chemical process of that particular factor.

Table-4: Variance explained by each factor for Pre monsoon waters

Rotated Factor Pattern of Water Analysis of East Godavari Pre monsoon data					Final
	Factor-1	Factor-2	Factor-3	Factor-4	Communalities
pH	0.00974	-0.11256	0.92926	0.06426	0.88042409
EC	0.85643	0.43429	0.15868	0.16952	0.97599702
TDS	0.85609	0.43487	0.15837	0.17023	0.9760597
TH	0.69646	0.23383	-0.39587	-0.26867	0.76863005
TA	0.72367	-0.1192	0.52341	0.40216	0.97359768
Na^{+}	0.8788	0.28127	0.24329	-0.14307	0.93106107
K^{+}	-0.14402	0.14902	-0.08393	0.86451	0.79736916
Ca^{+2}	-0.23724	0.18302	-0.23543	-0.84272	0.8553764
Mg^{+2}	0.87463	0.12587	-0.26205	0.2561	0.91508113
F^{-}	0.87844	0.25192	0.28592	0.05116	0.9194964
Cl^{-}	0.69337	0.60213	0.0063	-0.25567	0.90873233
SO_4^{-2}	0.44187	0.64357	0.04689	0.51114	0.87290194
NO_3^{-}	0.38211	0.85516	-0.03682	-0.04016	0.88027379
PO_4^{-3}	0.20919	0.51757	0.76716	-0.01415	0.90038416
Eigen Value	7.31796784	2.44594456	1.70220795	1.08926457	
Total Variance	5.7269617	2.4493225	2.2086756	2.1704251	12.55538492
%Variance	45.6135892	19.50814344	17.59146067	17.28680653	
Cumulative %	45.6135892	65.12173264	82.71319331	99.99999984	

Table-5: Variance explained by each factor for Post monsoon waters

Rotated Factor Pattern of Water Analysis of East Godavari post monsoon data					Final
	Factor1	Factor2	Factor3	Factor4	Communalities
pH	0.11782	0.16039	0.80947	-0.02477	0.69546428
EC	0.96169	0.15609	0.05798	-0.02185	0.95304847
TDS	0.96175	0.15578	0.05849	-0.02217	0.95314065
TH	0.60147	0.61361	0.17608	0.02677	0.7700032
TA	0.82672	0.17457	0.01505	0.41167	0.88364708
Na^{+}	0.87619	0.24872	0.11633	-0.36442	0.97589798
K^{+}	-0.08472	-0.18373	0.02698	0.94804	0.94043588
Ca^{+2}	-0.31766	-0.74358	-0.11329	0.41244	0.83676037
Mg^{+2}	0.60525	0.73143	0.17825	-0.05193	0.93579342
F^{-}	0.89905	0.21547	0.18365	-0.09166	0.89684804
Cl^{-}	0.83758	-0.05312	0.03286	-0.41739	0.8796626
SO_4^{-2}	0.01599	0.35559	-0.7222	0.03226	0.6493155
NO_3^{-}	0.60264	-0.62498	0.23895	0.07539	0.81655608
PO_4^{-3}	0.12885	0.22012	0.81915	0.05637	0.73923539
Eigen Value	6.93915545	1.97224369	1.76367816	1.25073166	
Total Variance	6.0409112	2.2796252	2.0366048	1.5686677	11.92580894
%Variance	50.65410012	19.1150572	17.07728851	13.15355384	
Cumulative %	50.65410012	69.76915731	86.84644582	99.99999966	

Results and Discussion

For pre monsoon season, the first four factors show Eigen values >1, hence these four factors were considered. In the post monsoon period also four factors have Eigen values>1 and hence four factors were considered.

Pre Monsoon:

Factor-1: The pre monsoon factor-1 loaded with EC, TDS, TH, TA, F^{-} and Cl^{-} (Table-4) indicating the Dissolved Solids. Higher values of total hardness also indicate the presence of calcium and Magnesium ion concentration which can attribute to the hardness of water as well as the encrustation nature of these values and also become a signature of Magnesium Hazard of the waters. Higher levels of TA indicate the unpleasant taste of waters. Concentrations of Na indicate the leaching and dissociation of secondary salts in the pore spaces. Higher loading of chloride indicate the corrosiveness nature of waters. Fluoride concentration can also become an indication for contamination. Factor accounts for 45.61% of the variance concentration of the ground water samples and is a higher percentage than attributed to the other factors.

Factor-2: Pre monsoon samples include mainly sulphate and Nitrate and this factor accounts for 19.50% of variance. The concentrations of sulphate indicate the occasional discharge of effluents while the concentration of Nitrate indicates the discharge of waste water from septic tanks transfer and occasional discharge of agricultural runoffs.

Factor-3: is represented by Phosphate and this factor accounts for 17.75% of variance. The higher loading of phosphate is an indication of excessive interaction of water with aquifer formation due to the fertilizer utilization.

Factor-4: accounts for 17.28% of variance and associated with potassium and indicates the chance of percolation of the ions into the aquifer due to higher residential time.

Post Monsoon:

Factor-1: The post monsoon factor-1 is loaded with EC, TDS, TA, Na^+, F^-, Cl^-, No_3^- and accounts for 50.65% of variance. The higher concentration of EC and TDS indicate the saline nature and the presence of soluble solid content in waters. Higher TA can contribute unpleasant taste to waters. Higher concentration of Na^+ indicates the leaching and dissociation of secondary salts in the pore spaces. Higher loading of Cl^- indicates the corrosive nature of waters while the fluoride concentrations can indicate the cause of contamination. Loading of Nitrate may also be due to occasional discharge of agricultural run-off from surroundings in to aquifers,

Factor-2: Factor-2 of Post Monsoon season is represented by the large loading of TH and Mg and account for 19.11% of total variance. Higher values of TH indicate encrustation nature of waters on water supply systems and making the waters unsuitable for domestic purposes. Larger loadings of Magnesium are an indicator of Magnesium hardness of waters which can deplete the quality of soil in the study area.

Factor-3: Factor -3 of Post Monsoon season is associated with pH and Po_4^{3-} and accounts for 17.07% of total variance. Values of pH indicate the nature of waters while the higher concentrations of Phosphate indicate the occasional discharge of agricultural run-off from the surrounding areas in to the aquifer.

Factor-4: Factor-4 of Post Monsoon season is represented by the loading of K^+ ion concentration and indicates the presence of dissolved salt content in waters.

Conclusion

The result of multivariate statistical analysis as applied to the chemical analytical data set of ground water in the present study provides an insight into the underlying factor controlling hydro geochemical processes in the region. Further factors in pre monsoon period indicating Factor-1 (EC,TDS,TH,Na^+,Mg^{2+},F^-,Cl^-), Factor-2($SO_4^{2-,}$ NO_3^-), Factor-3 (pH, PO_4^{3-}) and Factor -4 (K^+) expected from the data set represent the signature of the presence of dissolved solids encrustation of waters, unpleasant taste of water and Magnesium Hazard of Ground waters.

These factors in post Monsoon season indicating factor -1 (EC, TDS,TA , Na^+,F^-,Cl^-, NO_3^-). Factor-2 (TH,Mg^{2+}) Factor-3 (pH,PO_4^{3-}) and Factor-4 (K^+) resulted from the data set also indicate the signatures of dissolved solids unpleasant taste, encrustation and corrosive natures and Magnesium hazard of waters.

In the present study the chemical contamination of ground waters in these two seasons under study (pre and post Monsoon) are very well represented by the factors with the loading of EC,TDS, TH, TA, the anthropogenic signatures are also well demonstrated by the analytical data for the cause of ground water pollution. This technique can be extended to all coastal aquifer as a complement to standard hydro geochemical methods. In addition, the numerical analysis can help to resolve ambiguities and provide unique hydro chemical information.

References

1. Moharir, A., D.S. Ramteke, C.A. Moghe, S.R. Wate and R. Sarin (2002) Surface and ground water quality assessment in Ramanathapuram District. Ind. J. Environ. Protect., 22(9), 970-977.
2. Yanggen, D.A. and S.M. Bom (1990) Protecting ground water quality in managing local and use. J. Soil Water Conser., 45(2), 270-210.
3. Shane. S., Jerzy. J., (2003) Hydrochemistry and isotopic composition of Na-HCO3-rich ground waters from the Ballimore Region, Central New South Wales. Australia. Chem. Geol., 2011(1-2).
4. Cronin. A.A., Barth, J. A.C., Eliot. T., Kalin, R. M., (2005) Recharge velocity and geochemical evolution for the Permo-Triassic Sherwood sandstone, Northern Ireland. J. Hydrol., 315(1-4), 308-324.
5. Allen, S.K, Allen, J.M., Lucas, S. (1991) Concentration of contaminants in surface water samples collected in west-central Indiana impacted by acid mine drainage. Environ. Geol. 17,185-194.
6. Choubey, V.D. (1991) hydrological and environmental impact of coal mining. Jahria coalfield, India. Environ. Geol. 17, 185-194.
7. Galero, D.M., Pesci, H.E., Depetris, P.J. (1998) Effects of quarry mining and of other environmental impacts in the moluntainous Chicam-Toctina drainage basin (Cordoba, Argentina). Environ. Geological Survey of India Contributed by Desert and Environmental Geology Division, Jaipur. 34, 159-166.
8. http://forecast.weather.gov
9. Watzlaf GR (1995) Human DM lines tones of passive systems for the treatment of mine drainage. 17th Annual Association of Abandoned Mine Lands Conf.(French Link, IN), pp:186-199.
10. Watzlaf GR, Schroeder, KT Kairies C, (2000) Long-term performance of alkalinity producing passive systems for the treatment of mine drainage. Proc of the National Meeting of the American Society for

Surface Mining and Reclamation(Tampa,FL), pp:262-274.
11. APHA (1992) standard method for the examination of water and waste water, American public Health Association, Washington, 19th ed.,.
12. Davis JC, (1973) Statistics and data analysis in geology. Wiley, New York:, pp, 550.
13. Dalton MG & Upchurch SB, (1978) Interpretation of hydrochemical facies by factor analysis. Ground water 16, 228-233.