Characterisation of Groundwater Quality of Huvinhalla Watershed, Karnataka, India

Krishna.N.Kulkarni [1], G.S.Pujar [2]
Department of Studies in Geology, Karnataka University, Dharwad [1],
Associate Professor, Department of studies in Geology, Karnataka Science College, Dharwad [2]
Email: krisdwd@gmail.com [1], ganapatipujar@yahoo.co.in [2]

Abstract- The present work deals with the chemical characteristics of Huvinhalla watershed from Koppal District of North Karnataka. The granitic rocks are the litho units in Huvinhalla watershed. Ground water occurs under unconfined conditions. Ground water samples are collected from watershed in pre and post-monsoon seasons. The characteristics of the groundwater are studied based on the classification proposed by Piper, Back, Scholler, Souline, Alekin, and Durov. This study reveals that quality of ground water is controlled by the characteristic of litho units of the area.

1. INTRODUCTION

A quality of groundwater is a significant part of the hydrogeological study. The groundwater characteristics help in understanding nature of groundwater and its use for different purposes. Normally, groundwater acquires its quality by weathering of minerals from surrounding rocks and inturn the chemical reaction between the weathered minerals and water. The quality of groundwater changes due to contamination of domestic or industrial effluents. The quality of groundwater also depends on groundwater movement within the aquifer system. The aquifers with high hydraulic gradient have little chance for interaction with minerals in rocks where as aquifers with low hydraulic gradient have more time for interaction. In the present study, the chemical characteristics of ground water are studied in Huvinhalla watershed, Karnataka, India.

2. ABOUT THE STUDY AREA

In the present study, Huvinhalla watershed is considered (Latitude $15^0 17'$N to 15^0 30'N and Longitude 76^0 10'E to 76^0 23'E). The Huvinhalla watershed is in Koppal district and the area is as located in toposheet numbers 57 A/3 and 57 A/7. The watershed experiences arid to semi arid climatic conditions with little rains during SW monsoon seasons (June-Sept) and slightly better rains during NE-monsoon (Nov-Jan). Huvinhalla stream is non perennial and seasonal (August to September). The summers are hot (40-42^{0}C) and winters are cold (15-20^{0}C). The vegetations are scanty with a few trees of tamarind and neem. However thorny bushes are in plenty.

The Huvinhalla stream flows on Closepet granites of late Archaean period. The granites of Huvinhalla watershed are less weathered. There are few basic dykes and numerous acidic quartz veins cutting across the granites. The watersheds receive 400 to 500 mm of rains annually. In Huvinhalla watershed there are prominent outcrops of granite in the form of mounds and small hillocks. Huvinhalla watershed has part of rain water seeping into groundwater and part of it flows off these watersheds and join Tungabhadra river. The groundwater in Huvinhalla watershed occurs under water table conditions or unconfined conditions. The groundwater is around 20 to 25 m depth. Study area is represented in Fig. 1

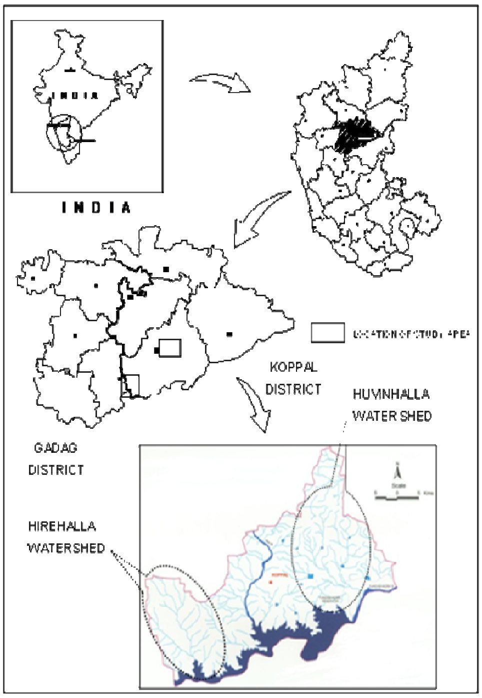

Fig 1 : Study area – Huvinhalla Watershed, Koppal District, Karnataka, India

3. METHODOLOGY

In the present study groundwater samples are collected in the month of May (as pre-monsoon samples) and in month of November (as post-monsoon samples). In both seasons 53 samples are collected from Huvinhalla. The samples are collected in 2 liter polyethylene cans after rinsing them All the samples are collected from regularly used bore wells. The samples were analysed for cations and anions. The estimated cations are Ca,Mg,Na,K and Fe and anions are SO_4 ,Cl,HCO_3,NO_3 and F. In addition to these constituents EC, TDS, pH and TH were also determined. The samples were analysed using standard procedure of APHA (1980). The minimum, maximum and average values of the above said constituents for both seasons of Huvinhalla watershed are given in Table 1.

Table 1: Premansoon - Maximum, Minimum and Average values

Parameters	**PREMONSOON**		
	Min	**Max**	**Avg**
EC	220	3900	1301.32
TDS	140	2420	812.08
pH	6.5	8.1	7.56
TH	55	1060	352.09
Ca	13	250	85.75
Mg	5.47	105.71	33.47
Na	17	305	102.53
K	Traces	26.00	3.03
Fe	Traces	0.70	0.41
SO_4	1.30	115.00	27.96
Cl	21.00	615.00	168.32
HCO_3	63	522	257.08
NO_3	7.50	128.00	48.15
F	Traces	2.50	1.30

All parameters except EC and pH in mg/lit. EC in µmhos/cm

Table 2: Postmansoon - Maximum, Minimum and Average values

Parameters	POSTMONSOON		
	Min	Max	Avg
EC	300	2900	1362.26
TDS	185	1800	845.08
pH	7	8	7.33
TH	70	674	319.51
Ca	18	189	83.45
Mg	6.08	79.46	26.94
Na	1	280	79.98
K	5	138	21.91
Fe	Traces	0.80	0.09
SO_4	5	125	41.77
Cl	19	434	142.74
HCO_3	25	420	224.15
NO_3	2.60	87.60	28.37
F	Traces	3.20	1.40

All parameters except EC and pH in mg/lit. EC in µmhos/cm

4. CHEMICAL CHARACTERISTICS

The groundwater of both watersheds is free from any colour or odour and they do not show any turbidity. The normal taste of groundwater in Huvinhalla watershed is slightly bracksih. The TDS, EC and TH values reveal that the Huvinhalla watershed samples are slightly saline. The concentration of most of cations and anions is less in Huvinhalla watershed samples. This is true in both seasons. These characteristics are presented in fig 2, as histogram.

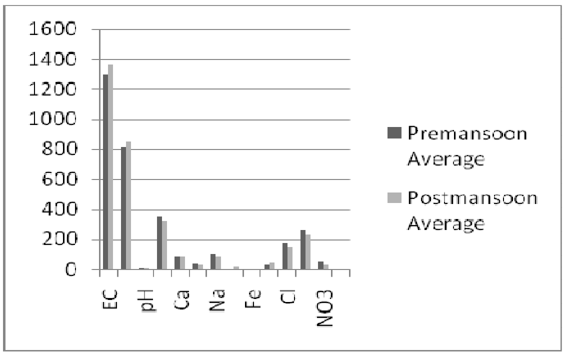

Fig 2: Pre and Post monsoon average values of water quality in Huvinhalla watershed

5. CLASSIFICATION OF WATER

In the present study the groundwater samples are classified to know their chemical characters. The classification proposed by Piper (1944), Back (1966), Scholler (1959), Souline (1948), Alekin (1962), Durov (1956), are adopted.

5.1. *Pipers Classification (1944)*

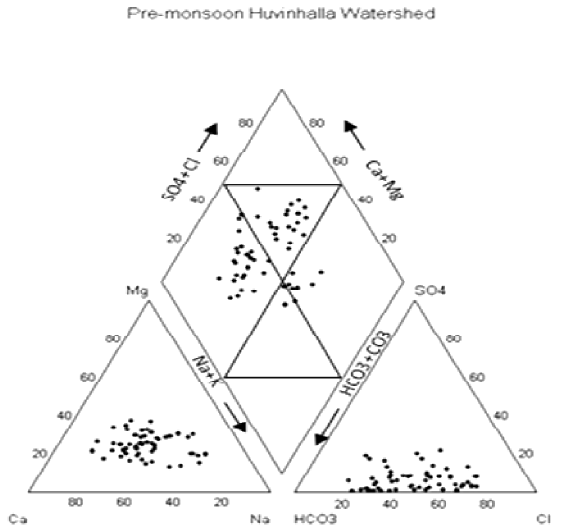

Fig 3 Piper Trilinear Diagram of Huinhalla watershed for pre monsoon values

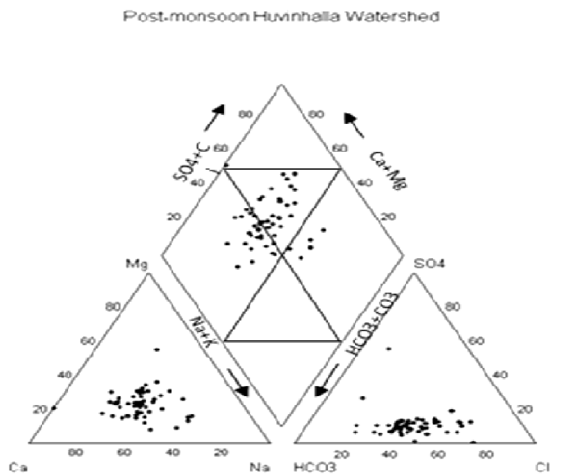

Fig 4 Piper Trilinear Diagram of Huinhalla watershed for post monsoon values

This classification utilized to identify hydro geochemical types of groundwater. Accordingly, different hydro chemical types of groundwater are identified from Huvinhalla watershed Fig 3and Fig.4 These characters are represented in Table 3. The Table 3 reveals different hydro chemical types for samples of both seasons in watershed. The pre-monsoon samples of Huvinhalla show that 24 samples are of mixed salinity, 22 samples have secondary alkalinity and only 7 samples show primary salinity. The post-monsoon samples of Huvinhalla watershed shows that 26 samples are of mixed type, 21 samples have secondary alkalinity and only 6 samples primary salinity.

Table 3 Piper's Classification

Classification	Field	Pre-monsoon	Post-monsoon
Alkaline earths (Ca+Mg) exceeds alkalies (Na+K)	Area 1	44	47
Alkalies (Na+K) Exceed alkaline earths (Ca+Mg)	Area 2	9	6
Weak Acids (HCO_3+CO_3) exceed strong acids (SO_4+Cl)	Area 3	24	21
Strong Acids (SO_4 + Cl) exceeds weak acids (HCO_3+CO_3)	Area 4	29	32
Carbonate hardness (secondary alkalinity) exceeds 50% i.e.the chemical properties of water are dominated by alkaline earth (Ca+Mg) and weak acids (HCO_3+CO_3).	Area 5	22	21
Non-Carbonate Hardness (Cl+SO_4) or secondary salinity exceeds 50%.	Area 6	0	0
Non-carbonate alkali (primary salinity) exceeds 50% i.e. chemical properties are dominated by alkalies and strong acids(primary salinity)	Area 7	7	6
Carbonate alkali (primary alkalinity) exceeds 50%	Area 8	0	0
None of the cation and anion pairs exceed 50%(mixed type)	Area 9	24	26

5.2. ***Back's Classification(1966)***

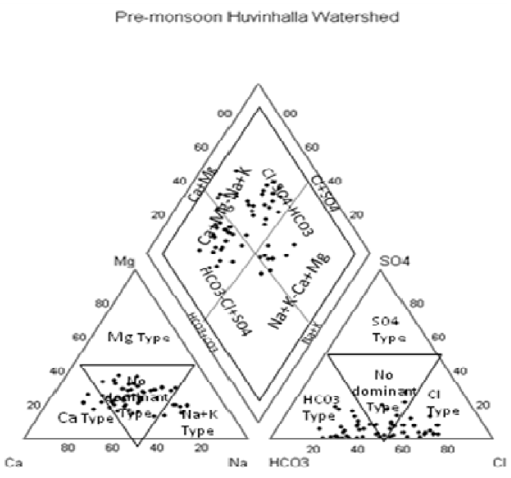

Fig 5 : Back's Trilinear Diagram of Huvnhalla watershed for post monsoon values

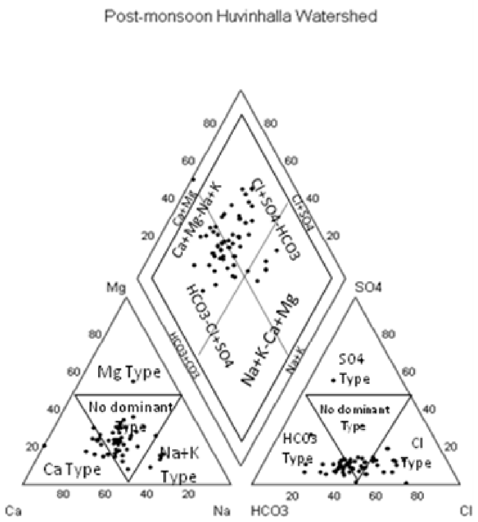

Fig 6: Back's Trilinear Diagram of Huvnhalla watershed for post monsoon values

This classification is used to identify hydrochemical facies in groundwater (Fig.5 and Fig.6). After plotting in Back's diagram the identified cation and anion facies are shown in Table 4. Pre-monsoon samples of Huvinhalla show that 44 samples belongs Ca+Mg-Na+K cation facies and 9 samples belongs to Na+K-Ca+Mg cation facies.31 samples are HCO_3 - Cl+SO4 anion facies and 22 samples are of Cl+SO_4- HCO_3 facies. The post-monsoon Huvinhalla watershed samples show that 49 samples belong to Ca+Mg-Na+K cations facies and 4 samples belong Na+K-Ca+Mg cation facies.33 samples are of HCO_3 - Cl+SO4 anion facies and 20 samples are of Cl+SO4-HCO_3.

Table 4 Back's Classification

Classification		Pre-monsoon	Post-monsoon
Cation Facies	Ca-Mg	0	0
	Ca+Mg-Na+K	44	49
	Na+K-Ca+Mg	9	4
	Na+K	0	0
Anion Facies	HCO_3-CO_3	0	0
	HCO_3-Cl+SO_4	31	33
	Cl+SO4-HCO3	22	20
	Cl+SO4	0	0

5.3. ***Scholler's Classification***

This classification is based on index of Base Exchange. Here classification based on the quantity of Cl, SO_4, HCO_3+ CO_3.The details of these characters are given in Table 5, 6 and 7.

5.3.1 Based on Chloride concentration: Pre-monsoon samples of Huvinhalla watershed shows that all 53 samples belongs normal chloride class. Post-monsoon samples Huvinhalla watershed show that all 53 samples belong to normal chloride water class.

Table 5 Back's Classification

Classification		Pre-monsoon	Post-monsoon
Super Chloride Water	>700 meq	0	0
Marine Chloride Water	700-420 meq	0	0
Strong Chloride Water	420-140 meq	0	0
Medium Chloride water	140-40 meq	0	0
Oligo Chloride Water	40-15 meq	0	0
Normal Chloride Water	<15 meq	53	53

5.3.2 Based on SO4 concentration:

Pre-monsoon samples of Huvinhalla watershed show that all 53 samples belong normal sulphate water class. Post-monsoon samples Huvinhalla watershed show that 44 samples belong normal sulphate water class and 9 samples belong oligo sulphate water class.

Table 6 Scholler's Classification Based on SO_4 Concentration.

Classification		Pre-monsoon	Post-monsoon
Super Sulphate water	>58 meq	0	0
Sulphate water	58-24 meq	0	0
Oligo Sulphate water	24-6 meq	0	9
Normal Sulphate water	<6 meq	53	44

5.3.3 Based on HCO_3 - CO_3 concentration:

Pre-monsoon samples of Huvinhalla watershed show that 42 samples belong normal carbonate water class, 6 samples belongs super carbonate water class and 5 samples belong under carbonate water class. Post-monsoon samples of Huvinhalla watershed show that 48 samples belongs normal carbonate water and 5 samples belong to under carbonate water.

Table 7 Schollers Classification Based on HCO_3 - CO_3 Concentration

Classification		Pre-monsoon	Post-monsoon
Super Carbonate Water	>7 meq	6	0
Normal Carbonate Water	2-7 meq	42	48
Under Carbonate Water	<2 meq	5	5

Further, Scholler classified water into 3 classes as shown Table 8, based on chloride and alkali constituent. 47 pre-monsoon samples of Huvinhalla basin belong to positive base index and only 6 samples belongs to negative index of base exchange. 29 post- monsoon samples of Huvinhalla watershed samples belongs to positive index of base exchange and 24 samples belong negative base index of exchange. The above explanation reveals the groundwater samples of both water shed exhibit '+' and '-' ve base exchange characteristics.

Table 8 Schollers Classification Based on chloride and alkali Concentration

Classification		Pre-monsoon	Post-monsoon
+ ve Index of base exchange	Cl>Na	47	29
= equilibrium	Cl=Na	0	0
-ve Index of base exchange	Cl<Na	6	24

Scholler differentiated different classes based on percentage of cations and anions. Based on this classification of groundwater samples, details are given in Table 9. 22 pre-monsoon samples of Huvinhalla watershed shows Ca>Na>Mg class, 15 samples belong Na>Ca>Mg. 10, 5, 1 belong to Ca>Mg>Na, Na>Mg>Ca and Mg>Na>Ca classes respectively. 31 post-monsoon samples in Huvinhalla watershed belongs Ca>Na>Mg, 10 samples belong to Na>Ca>Mg, 2 samples each from classes Na>Mg>Ca and Mg>Na> Ca and only one sample from this post monsoon season belongs to Mg>Ca>Na.

Table 9 Scholler's Classification Based on percentage of anions

Classification	Pre-monsoon	Post-monsoon
Na>Mg>Ca	5	2
Na>Ca>Mg	15	10
Mg>Na>Ca	1	2
Mg>Ca>Na	0	1
Ca>Na>Mg	22	31
Ca>Mg>Na	10	0

Based on anions percentage (Table 10), 53 pre-monsoon samples in Huvinhalla watershed belongs to $Cl>SO_4>CO_3$ and 51 post-monsoon samples belongs to $Cl>SO_4>CO_3$. The above explanation reveals that maximum samples of Huvinhalla watershed belongs to $Cl>SO_4>CO_3$ class.

Table 10 Scholler's Classification Based on percentage of cations.

Classification	Pre-monsoon	Post-monsoon
$Cl>SO_4>CO_3$	53	51
$Cl>CO_3>SO_4$	0	0
$SO_4>Cl>CO_3$	0	2
$SO_4> CO_3>Cl$	0	0
$CO_3>Cl>SO_4$	0	0
$CO_3>SO_4>Cl$	0	0

5.4. *Sovelin's Classification (1948)*

In this classification 4 classes are identified based on ionic ratios as shown in Table 11. 34 pre-monsoon samples of Huvinhalla watershed belongs $Na\text{-}SO_4$ water class and 19 samples belong to $Na\text{-}HCO_3$ class. 51 post-monsoon samples of Huvinhalla watershed belong to $Na\text{-}SO_4$ water class, 2 water samples belongs $Na\text{-}HCO_3$.

Further 52 pre-monsoon Huvinhalla watershed samples belong to Mg-Cl water class and only one sample belong to Ca-Cl class. 50 post- monsoon samples of Huvinhalla watershed belongs to Mg-Cl classes and only 3 samples belong Ca-Cl water class. The above explanation reveals that maximum number of samples belong to $Na\text{-}SO_4$ and Mg-Cl water classes.

Table 11 Sovelin's Classification Based ionic ratios

Classification		Pre-monsoon	Post-monsoon
$Na\text{-}SO_4$ Water	$Na\text{-}Cl/SO_4 <1$	34	51
$Na\text{-}HCO_3$ Water	$Na\text{-}Cl/SO_4 >1$	19	2
Mg-Cl Water	Cl-Na/Mg<1	52	50
Ca-Cl Water	Cl-Na/Mg>1	1	3

5.5. *Alikin's Classification (1962)*

In this classification 3 classes are identified made based on ionic ratio as shown Table 12. 45 samples of pre and post-monsoon samples of Huvinhalla watershed belong to Type-3. 11 pre-monsoon samples belong Type-2 and 4 samples belong Type-1. 5 post-monsoon samples belong to Type-1.The above explanation reveals that maximum samples number of both basins belong to Type-3 $(HCO_3+SO_4)>(Ca+Mg)$.

Table 12 Alikin's Classification Based ionic ratios

Classification		Pre-monsoon	Post-monsoon
TYPE 1	$(HCO_3)>(Ca+Mg)$	4	3
TYPE 2	$(HCO_3)<(Ca+Mg) < (HCO_3+SO_4)$	11	5
TYPE 3	$(HCO_3+SO_4) < (Ca+Mg)$	45	45
TYPE 4	$HCO_3=0$	0	0

5.6. *Durov's Classification (1956)*

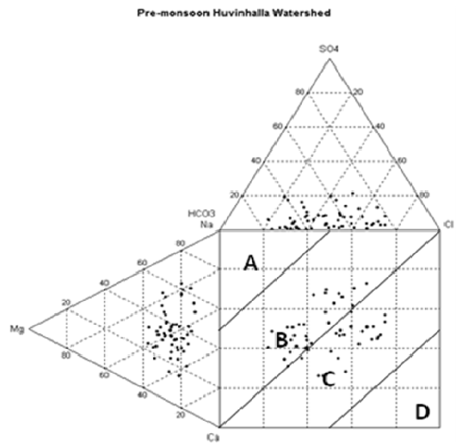

Fig 7: Durov's Diagram of Huvnhalla watershed of pre monsson values

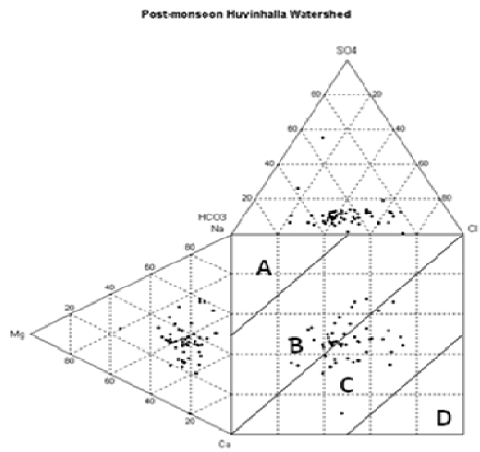

Fig 8: Durov's Diagram of Huvnhalla watershed of post monsson values

This classification is used to know the contamination within the water samples as shown in Table 13. 30 pre-monsoon samples of Huvinhalla watershed show no contamination and 23 samples moderate quality. 29 post-monsoon samples of Huvinhalla watershed belong to moderate quality and 24 samples show no contamination.

Table 13 Durov's Classification

Classification		Pre-monsoon	Post-monsoon
A	Pure Water	0	0
B	No Contamination	30	24
C	Moderate quality	23	29
D	High contamination of Na and Cl	0	0

6. CONCLUSIONS

Huvinhalla watershed comprises of the granites of archean period. The Huvinhalla experiences arid to semi arid climatic conditions. Huvinhalla watershed are secondary alkaline as per Piper (1944). Ca+Mg-Na+K cation facies, $Cl+SO_4$-HCO_3 and HCO_3-$Cl+SO_4$ anion facies are dominating in the watershed as per Back (1966). Based on ionic concentrations of Cl, HCO_3 and SO_4 in groundwater samples of Huvinhalla watershed, they belong to normal chloride water class, normal sulphate class, and normal carbonate class and a few samples belong to carbonate class as per Scholler's Classification (1959). Based on Cl and Na concentration maximum number of samples indicate positive and negative base exchange characteristics in the watershed as per Scholler (1959). Based on percentage of anionic concentrations, maximum number of samples indicate $Cl>SO_4>CO_3$ nature again as per Scholler (1959). Based on percentage of cation concentration maximum number of samples indicate Ca>Na>Mg nature in the watershed. Based on ion ratios of Na-Cl/SO_4 and Cl-Na/Mg, maximum number of samples belong to Na-SO_4 and Mg-Cl classes as per Sovelin (1948). Based on HCO_3, Ca+Mg, HCO_3+SO_4 ratios, maximum number of samples belong to $(HCO_3)<(Ca+Mg)<(HCO_3+SO_4)$ and $(HCO_3+SO_4)<(Ca+Mg)$ class as per Alikin (1962). In Durov's (1956) classification maximum number of samples belong to "No contamination" and "Moderate quality" class

The above said points enumerate that there is a significant variation in the chemical parameters of groundwater. These variations can be attributed to lithological characteristics, different kinds of weathering and due to chemical reactions.

Though the ionic content in this watershed is not alarming today, the process of dissolution of cationic or anionic ions into groundwater is in progress since time immemorial. This process of dissolution may lead to higher concentrations leading to more health related complications in years to come.

REFERENCES

[1] APHA.,1980: Standards method for the examination of water and wastewater. American Public health Association, 17th edition, Washington, D.C, pp-1500
[2] Back., 1966:Hydrochemical Facies and Groundwater Flow in Northern part of Atlantic coastal plan, U.S.G.S.Prof.Paper, No.498-a,pp.A42.
[3] Durov.P., 1956 : In Chillingar, G.V.Durov classification of Natural water and chemical composition of atmospheric precipitation in U.S.G.R; A review Trans. A. M. Geophysicist Union, Vol.37.PP.546-556.
[4] Piper.A.M.,1944:A Graphical procedure in the Geochemical interpretation of water analysis.Trans.Amer.Geophysics.Union.Vol.25,pp.914-928.
[5] Souline.,1948: In Scholler. H. 1962, LesEaux Soutrraines, Paris Masson p.642.
[6] Scholler.H.,1959: Geochemistary of groundwater, Arid zone hydrology recent development, UNESCO, 54.
[7] ALEKIN.O.A., 1962: Grundlagen der Wasserchemie.Eine Einfushrung in die chemie nature – licher wasser. 260. Uipzig: VEB Deatsch, verl.