American International Journal of Research in Humanities, Arts and Social Sciences

Available online at http://www.iasir.net

ISSN (Print): 2328-3734, ISSN (Online): 2328-3696, ISSN (CD-ROM): 2328-3688

AIJRHASS is a refereed, indexed, peer-reviewed, multidisciplinary and open access journal published by International Association of Scientific Innovation and Research (IASIR), USA
(An Association Unifying the Sciences, Engineering, and Applied Research)

Evaluation of Groundwater Quality and its Suitability for Drinking and Agricultural use in and around Hingoli Region, Maharashtra, India

Godbole Mahendra T. & Patode H.S.
School of Earth Sciences,
Swami Ramanand Teerth Marathwada University, Nanded (M.S.), India

***Abstract**: This study was conducted to evaluate factors regulating groundwater quality in an area with agriculture and drinking water as main use. 53 groundwater samples have been collected from in and around Hingoli Region, Maharashtra, India covers an area of approximately 36 Km^2 and underlain by the Deccan Trap lava flows of upper Cretaceous to Eocene age. Rapid development in recent years has led to an increased demand for water, which is increasingly being fulfilled by groundwater abstraction. Detailed knowledge of water quality can increase understanding of the hydrochemical system, to achieve this; a hydrochemical investigation is carried out in the study area. Groundwater samples were chemically analyzed for major physicochemical parameters in order to understand the different geochemical processes affecting the groundwater quality. Analytical results shows by taking into consideration of except RSC, overall, ratios such as SSP (Post-monsoon 2009-2011 87.41% are <50 & Pre-monsoon2010-2012 82.55% <50) indicates good quality of water.100% samples of study area from Post-monsoon 2009 to Pre-monsoon 2012, SAR are <10 shows excellent quality of water for agriculture and drinking water point of view. PI has assessed and all samples from every seasons of study area falls under the category of excellent to good i.e(0-25 excellent class). KR also shows that the overall all samples falls <1 indicates good quality of water*
***Keywords**: Groundwater analysis, Hingoli Region, irrigation water quality, Cretaceous to Eocene age.*

I. Introduction

The source of water supply to the area is through bore wells and dug wells. Irrigated agriculture is depend on adequate water supply of suitable quality. Water quality concern has been plentiful and readily available. For irrigation, the quality of water determines if optimum returns of from the soil can be obtained as the quality affects the soil, crop and water management. Nearly all water contains dissolve salts and trace elements, many of which results from the natural weathering of the earth's surface (Nahid Sultana, M. Aminul Haque & Syed Fazle Elahi, 2009). In most irrigation situations, the primary water quality concern is salinity levels, since salts can affects both the soil structure and crop yields. The elaboration and implementation of sustainable water use strategies based on the detailed data on the seasonal variation of the water quality that is strongly related to dilution processes taking place during high flow periods specially in post-monsoon seasons, and to the loads of soluble compounds carried by the return waters utilized for drinking and irrigation (Crosa, et al. ,2006).The results reveal that except some of the sample's parameters like, EC, TDS. All other quality parameters are safe for irrigation and drinking purpose. Groundwater in study area is utilized for both agricultural and drinking purposes hence the hydrochemistry is discussed in order to understand water rock interaction process and to investigate the concentration of the total dissolved constituent present in groundwater with respect to the standards of safe potable water.

Climate

Climate of the district is characterized by a hot summer and a general dryness throught the year except during the south west monsoon seasons, which is from June to September while October and November constitute the post-monsoon seasons.. The variation in rainfall from year to year is large and study area falls in drought prone area hence it is characterized by an erratic behaviour of rainfall.

Geology and Hydrogeology

The area consists of Deccan Trap encompassing different types of basaltic flows, separated by red bole. The basaltic lava flows belonging to Deccan volcanic province that flooded during upper Cretaceous to Eocene age.

The Stratigraphic sequence and lithology as indicated given below.

Formation	Age	Lithology
Deccan Trap	Upper Cretaceous to Eocene	Vesicular and Amygdaloidal Zeolitic Basalt inter bedded with red bole.

The prominent geological units observed in study area are the horizontally disposed basaltic lava flows and each flows has distinct two units. The upper layer consists of vesicular and amygdule zeolatic sasalt, and lower one is compact basalt. The study area consists of four types of rocks like compact amygdaloidal, vesicular and tachylytic basalt.

Hydrogeology

The area consists of Deccan Trap, encompassing different types of basaltic flows, separated by red bole. The occurrence of groundwater is found in shallow and deep aquifers. The Deccan Trap consists of four types of rocks like compact, amygdaloidal, vecicular, and tachylitic basalt. The groundwater is found in compact basalt due to the presence of secondary porosity, i.e. Fracture and joints in the rocks. Depth of the dug wells is from 5.18 to 54.8 mt. and 12.19 to 122 mt. for bore wells. The soil thickness is about 0.2 mt to 12.19 mt. and average is 2.94 mt. The chemical composition of groundwater of the study area is shown in Table 1. The chemical composition of the groundwater is controlled by nature of geochemical reaction, velocity and volume of groundwater flow, lithology, precipitation and role of human activity (Matthes and Harvey,1982; Reddy, Subba Rao and Reddy 1991, Bhatt and Sakalani, 1996.).

Hydrogeology

The area consists of Deccan Trap, encompassing different types of basaltic flows, separated by red bole. The occurrence of groundwater is found in shallow and deep aquifers. The Deccan Trap consists of four types of rocks like compact, amygdaloidal, vecicular, and tachylitic basalt. The groundwater is found in compact basalt due to the presence of secondary porosity, i.e. Fracture and joints in the rocks. Depth of the dug wells is from 5.18 to 54.8 mt. and 12.19 to 122 mt. for bore wells. The soil thickness is about 0.2 mt to 12.19 mt. and average is 2.94 mt. The chemical composition of groundwater of the study area is shown in Table 1. The chemical composition of the groundwater is controlled by nature of geochemical reaction, velocity and volume of groundwater flow, lithology, precipitation and role of human activity (Matthes and Harvey,1982; Reddy, Subba Rao and Reddy 1991, Bhatt and Sakalani, 1996.)

Hydrochemistry

The chemical constituents of groundwater are result of geochemical processes occurring due to the reaction of water and geologic materials (Appelo et al. 1996). The hydrochemistry of the groundwater assess on the basis of EC, TDS, Ca, Mg, TH, Na, K, NO_3, SO_4 etc. (Table-1.). During post-monsoon (2009, 2010 and 2011) and pre-monsoon seasons (2010, 2011 and 2012), it is observed that the average concentration of EC, TDS, Cl, Ca, Mg, TH, TA, are much more than the pre-monsoon seasons. The concentration of these elements increases in post-monsoon seasons may be due to the effects of leaching during rainy season (K. Srinivasamurthy, et. al 2009). The concentration of sodium (Na) was more in pre-monsoon and potassium (K) have remain constant values in both the seasons, it is indicates that lower geochemical mobility. Nitrate (NO_3) and sulphate (SO_4) shows more concentration indicate infiltration of surface water into groundwater during rainy season. Nitrogen in groundwater is mainly derived from fertilizer or nitrogen fixing bacteria leaching of animals dung in agriculture field, sewage and septic tank from city area or industrial influent through soil from MIDC to groundwater.

II. Study Area

The study area is a part of Kayadhu basin, bounded by latitudes $19^0 42'$ & $19^0 44'$ and longitudes $77^0 7'$ & $77^0 10'$ the area includes Hingoli City, is a head quarter of district located on the bank of Kayadhu River. Apart from this, the area consists of seven villages like Devulgaon Rama, MIDC area Hingoli, Andharwadi, Gadipura, Ganeshwadi, Warud Gawali etc.

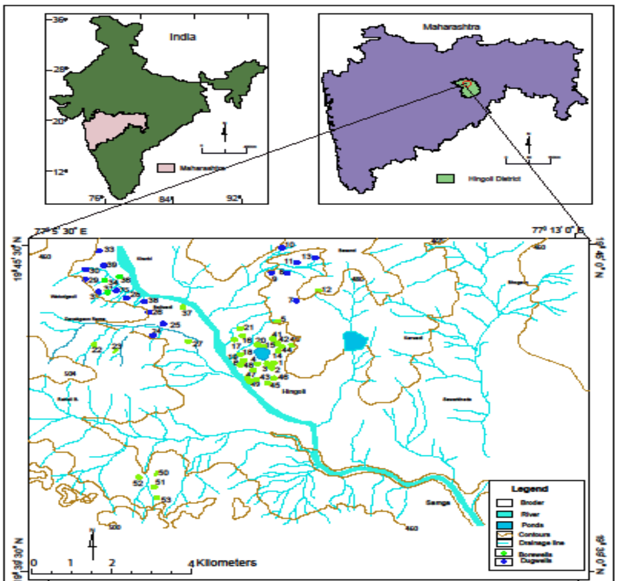

Fig1: Location Map of Study Area

The study area covers an area of about 36 sq.Km^2 (Toposheet 56E/2; Fig.1). The major sources of employment are agriculture, horticulture and animal husbandry. The MIDC area of Hingoli consists of some Industries like, PVC pipe Industry; oil industry etc.

III. Material and Methods

The current study was designed to investigate the condition of groundwater contamination in the study area. The chemical investigations of groundwater are results of chemical process occurring due to the reaction of water and geochemical materials (Appelo et.al.,1996). The hydrochemistry of the groundwater assessed on the basis EC, TDS, Ca, Mg, TH, Na, K, NO_3, SO_4 etc. Water quality parameters such as pH, EC, Temperature were analyzed immediately. Other parameters were later analyzed in the Laboratory of School of Earth Sciences, S.R.T.M. University, Nanded. Total dissolved solids (TDS) were computed by the multiplying the electrical conductivity (EC) by the factor (0.64) .Total Hardness (TH) as $CaCO_3$ and Calcium (Ca) were analysed titrimetrically, using standard EDTA. Magnessium (Mg) was calculated by taking the differential value between Total Hardness (TH) and calcium concentration chloride (Cl) was determined by titrimetrically by standard $AgNO_3$ titration. The content of the Sodium (Na)and Potassium (K) in ground water was estimated flame photometrically, employing Elico-flame photometer. Sulphate (SO_4) and Nitrate (NO_3) detected by U.V.Spectrophotometer. All parameters are expressed in (mg/l). Except pH units and electrical conductivity is expressed in micromoh/cm.

IV. Results and Discussion

The quality standards for drinking water have been specified by the World Health Organization (WHO) in 2004.The behavior of major ions (Ca, Mg, Na, K, HCO_3, SO_4, Cl) and important physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), and total hardness (TH) and the suitability of groundwater in the study area are discussed below.

Table 1. Physico-chemical parameters of groundwater and its comparison with standards

Parameters	WHO (1996)	Highest Desirabe	ISI (1995)	Post-monsoon 2009-2011			Pre-monsoon 2010-2012		
	MPL		MPL	Min.	Max.	Average	Min.	Max.	Average
pH	6.5	7.5-8.5	6.5-9.2	6.1	8.41	7.06	6.78	7.92	7.31
EC	1400	....	....	119.12	8971.1	2881.60	249.56	8557.17	2397.98
TDS	1500	500	1500	76.23	5741.5	1461.11	128.21	5101.5	1268.93
Cl	1000	250	1000	28.4	1012	444.20	10.6	829.2	229.07
Ca	500	75	200	5.88	184.4	786.4	15.16	169.26	72.46
Mg	100	50	100	12.23	99.8	53.50	4.44	97.68	47.05
TA($CaCO_3$)	......	300	600	32	1078	293.33	30	276.66	118.88
Na	22	......	....	5.2	68.03	23.98	3.5	40.7	19.52
K	.....	.....	......	0.1	7.8	3.59	0.1	6.4	2.88
SO_4	400	200	400	6	101	40.99	9	92	37
Na_3	45	....	45	10	90	43.51	10	86	39.05
TH	.....	....	....	45.09	645.12	266.39	10.06	554.4	219.78

Drinking suitability

The analytical results have been evaluated to ascertain the suitability of groundwater in the study area for drinking and agricultural uses. The analytical results for all the parameters for the groundwater samples in the study area from post monsoon 2009-2011and pre-monsoon 2010-2012 are presented in the Table1.

pH

pH is a measure of the balance between the concentration of hydrogen ions and hydroxyl ions in water. The pH of water provides vital information in many types of geochemical equilibrium or solubility calculations (Hem1985). The limit of pH value for drinking water is specified as 6.5–8.5 (WHO2004, 1996; ISI1993, 1995). The pH value of most of the groundwater samples in the study area varies from 6.1-8.41and average is 7.06 in post-monsoon 2009-2011 and 6.78-7.92 and average is 7.13 in pre-monsoon season from 2010-2012.

Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current (S. V. Sarath Prasanth.et.al. 2012.). It is used to estimate the amount of dissolved solids. It increases as the amount of dissolved mineral (ions) increases. In the study area, the value of conductivity ranged between 119.12 to 8971 and average is 2981.60 in post monsoon seasons of 2009-2011:S/Cm. The EC pre-monsoon season 2010-2012 is ranging from 249.56 to 857.17 and average is 239.7 The maximum concentration of electrical conductivity (EC) in the study is 8971 :S/Cm (0.25 ds/m) which is above WHO (1996) .This could be related toa slightly acidic condition (G.I. Obiefuna and A. Sheriff,2011).

Total Dissolved Solid (TDS)

Total Dissolved Solid (TDS) generally reflects the amount of minerals content that dissolved in the water, and this controls its suitability for use. High concentration of total dissolved solid may cause adverse taste effects. Highly mineralized water may also deteriorate domestic plumbing and appliances (G.I. Obiefuna and A. Sheriff,2011).In the study area, the concentration value of TD ranged between 76.23 to 5741 mg/L with the average value is 1461 in post-monsoon 2009-2011 and in pre-monsoon season the EC ranges from 128.21 to 5101.5 and average is 1268.93. The average values of post-monsoon 2009-2011 and pre-monsoon 2010-2012 is within the maximum permissible limit of WHO (1996). It must be said that the water is thus good for human consumption (domestic) and agricultural purposes.

Chloride (Cl^-)

A major ion that may be associated with Individual Septic Disposal System (ISDSS) is chloride (Canter and Knox, 1985). Chloride is present in all natural waters, usually in relatively small amounts; however, chloride also can be derived from human sources. Chloride is not effectively removed by the septic systems and therefore, remains in their effluent high concentration of chloride in water is known to cause no health hazard, hence, its readily available in almost all potable water. In the study area, the concentration of chloride is range between 28.4 to 1012 mg/L, and average is 444.20 in post- monsoon 2009-2011 and in case of premonsoon 2010-2012 Cl values ranges from 10.6 to 829.2 and average are 229.07 which is below the maximum allowable concentration of (WHO, 1996).

Calcium Ca^{2+}mg/L

Calcium contributes to the hardness of water and it is the fifth most common element found in most natural waters. The sources of calcium in ground water especially in sedimentary rocks are calcite, aragonite, gypsum and anhydride (G.I. Obiefuna and A. Sheriff,2011). The calcium concentration in the sampled well in the study area is 5.88 to 184.4 and average is 78.64 in post monsoon season 2009-2011 and in pre-monsoon season from 2010-2012 is ranging from 15.16 to 169.26 and average is 72.46. All the values of Ca are within the permissible limit of (WHO1996). The possible source of this calcium is limestone or gypsum.

Magnessium (Mg^{2+})

Magnesium is one of the most common elements in the earth’s crust. It is present in all natural waters. It is an important contributor to water hardness. The sources of magnesium in natural water are dolomites and mafic minerals (amphibole) in rocks. The solubility of dolomite in water depends on the composition. The concentration of Mg in study area are ranges from 12.23 to 99.8 and average is 53.50 in post- monsoon season 2009-2011 and 4.44 to 97.68 and average is 47.50 is recorded in pre-monsoon season 2010-2012. All the values of Mg in study area are within the permissible limit and the water quality is good for the health.

Total Alkalinity

Total alkalinity is a measure of the capacity of water or any solution to neutralize or “buffer” acids. This measure of acid-neutralizing capacity is important in figuring out how “buffered” the water is against sudden changes in pH. Alkalinity should not be confused with pH. pH is a measure of the hydrogen ion (H+) concentration, and the pH scale shows the intensity of the acidic or basic character of a solution at a given temperature. The reason alkalinity is sometime confused with pH is because the term alkaline is used to describe pH conditions greater than 7 (basic). T he most important compounds in water that determine alkalinity include the carbonate ($CO3^{2-}$) and bicarbonate (HCO3-) ions. Carbonate ions are able to react with and neutralize 2 hydrogen ions (H+) and the bicarbonate ions are able to neutralize H+ or hydroxide ions (OH-) present in water. The ability to resist changes in pH by neutralizing acids or bases is called buffering. One source of alkalinity is calcium carbonate ($CaCO_3$), which is dissolved in water flowing through geology that has limestone and/or marble. The concentration of total alkalinity is ranges from 32 to 1078 and average is 293.33 in post-monsoon season 2009-2011 and in pre- monsoon 2010-2012 season it is varies from 30 to 276.66 and average is 118.88. The highest desirable limit of total alkalinity of WHO (1996) is 300. In study area all the values are within the permissible limit.

Sodium (Na)

Sodium is an important constituent for determining the quality of irrigation water. Sodium bearing minerals like albite and other members of plagioclase feldspars, nephelene and sodalite weather to release the primary soluble sodium products (Biswajeet Pradhan, et,al.2011). Most sodium salts are readily soluble in water, but take no active part in chemical reactions. Sodium has wide variations in its concentration in ground water. The sodium content of the samples was determined by a flame photometer. Sodium content in the water samples varies between 5.2 to 68.03 and average 23.98 in post monsoon 2009-2011 and in pre- monsoon 2010-2012 it varies from 3.5 to 40.7 and average is 19.52.

Potassium

Although potassium is nearly as abundant as sodium in igneous rocks, its concentration in ground water is comparatively very less as compared to sodium nearly one-tenth or one-hundred that of sodium(Biswajeet Pradhan, et,al.2011). This is due to the fact that the potassium minerals are resistant to decomposition by weathering. The potassium concentration in the water was deter-mined with the help of Flame photometer.

Analysis of water samples in the study area indicates that potassium value varies between 0.1 to 7.8 and average is 3.59 ppm in post-monsoon 2009-2011 and also detected in the range of 0.1-6.4 and average is 2.88 in pre-monsoon 2010-2012.

Sulphate (SO_4^{2-}) mg/L

Sulphate occurs in water as the inorganic sulphate salts as well as dissolved gas (H_2S).Sulphate is not a noxious substance although high sulphate in water may have a laxative effect. The concentration of sulphate (SO_4^{2-}) in study area is between 6 to 101with the average value of 40.99 in post-monsoon 2009-2011mg/L. The detected values of SO_4 in pre-monsoon season range between 9 to 92 and average is 37 mg/L. The highest permissible limit of SO_4 is 300 all the values are below this limit. The high concentration of sulphate in the other settlements is likely due to the dissolution of gypsum.

Nitrate (NO_3):

Sources of nitrate in water include human activity such as application of fertilizer in farming practices, human and animal waste (which relate topopulation). The concentration of $NO_{3\ IS}$ The concentration of nitrate (NO_3) Is ranges from 10 to 99 and average is 43.51in post-monsoon season 2009-2011 and it varies from 10 to 86 and average is 39.05 in pre-monsoon season 2010-2012 . Some of the localities of study area rises up above the permissible limit of WHO. The possible cause may be the highly populated and the human waste management system is poor (shallow pit toilets and open defecation in thebushes) and also the use of nitrogenous fertilizer and animal dung in farming is a likely source of input into the ground water of this chemical (G.I. Obiefuna and A. Sheriff,2011).

Total hardness (TH)

The total hardness is varying from 49.05 to 645.12 and average IS 266.39 in post-monsoon 2009-2011 and in pre-monsoon it ranges from 10.06 to 554.4 and average is 219.78mg/L. Groundwater of the entire study area lies within the maximum permissible limit prescribed by ISI. Sawyer and McCarty (1967) classified groundwater, based on TH, as ground water with TH\75, 75–150, 150–300 and [300 mg/l, designated as soft, moderately hard, hard and very hard, respectively.

Assessment of ground water quality for irrigation Purposes

Assessment of the groundwater quality of the study area was done to determine its suitability for domestic and agricultural purposes water for each of these purposes is require meeting certain safety standard that have been set by either World Health Organization or agencies (G.I. Obiefuna and A. Sheriff,2011).

Agricultural use

Water for agricultural purposes should be good for both plant and animals. Good quality of
Waters for irrigation are characterized by acceptable range of:

- The Soluble Sodium Percentage (SSP)
- The Residual Sodium Bicarbonate (RSBC)
- The Magnesium Adsorption Ratio (MAR)
- The Kellys Ratio (KR)
- The Total Dissolved Solids (TDS)
- The Permeability Index (PI)

The results of the different irrigation indices for rating irrigation water quality are presented in Table 4.

Sodium Adsorption Ratio (SAR):

The Sodium Adsorption Ratio (SAR) was calculated by the following equation given by Richards (1954) as:
$SAR=Na/\sqrt{}(Ca^{2+}Mg^{2+})/2$, where all the ions are expressed in meq/L.

The sodium adsorption ratio gives a clear idea about the adsorption of sodium by soil. It is the proportion of sodium to calcium and magnesium, which affect the availability of the water to the crop. The sodium adsorption ratio of groundwater obtained in the present study are 0.10 to 0.56 with the average values are 0.33 in post monsoon season 2009, in post monsoon-season 2010 it varies from 0.10 to 0.62 and average is 0.37 and in post-monsoon season 2011 the values of SAR are 0.83 to16.95 and average is 03.52. The SAR values of pre-monsoon 2010-2012 are also <10. It means that all the water samples.

Table 2. Classification of groundwater (Post-monsoon-2009-2011) on the basis of SAR

	Range	Water Class	Samples	%age
Post-monsoon 2009-	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-
	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-
	Range	**Water Class**	**Samples**	**%age**
Post-monsoon 2010	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-
	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-
	Range	**Water Class**	**Samples**	**%age**
Post-monsoon -20011	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-

	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-

Table 3. Classification of groundwater (Pre-monsoon-2010-2012) on the basis of SAR

	Range	Water Class	Samples	%age
Pre-monsoon 2010	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-
	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-
	Range	**Water Class**	**Samples**	**%age**
Pre-monsoon 2011	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-
	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-
	Range	**Water Class**	**Samples**	**%age**
Pre-monsoon 2012	< 10	Excellent (S_1)	53	100
	10-18	Good (S_2)	-	-
	18-26	Doubtful (S_3)	-	-
	>Unsuitable	Unsuitable (S4)	-	-

All samples from post-monsoon 2009-2011 and pre monsoon 2010-2012 are falling within the excellent categories. Overall SAR shows that the ground water quality is suitable for irrigation.

The Soluble Sodium Percentage (SSP)

The Soluble Sodium Percentage (SSP) was calculated by the following equation (Todd, 1995):

SSP = (Na + K) x 100/Ca^{2+} + Mg^{2+}+Na + K. Where, all the ions are expressed in meq/L. Sodium percent is an important factor for studying sodium hazard. It is also used for adjudging the quality of water for agricultural purposes. High percentage sodium water for irrigation purpose may stunt the plant growth and reduces soil permeability (Joshi et al., 2009). The soluble sodium percentage values of shallow groundwater in the study area ranges between 11.61 to 67.46 and average is 29.11 in post monsoon 2009, the values of SSP are ranges from 10.39 to 74.61 and average is 34 in post monsoon 2010 , and in post monsoon 2011 it ranges from 12.82 to 344.86 and average is 42.78 . In post monsoon season 2011, 84.90% SSP of study area are <50 it indicates good quality of water for irrigation purpose. While 15.09% is more than 50 it indicates that the unsuitable water quality for irrigation. Over all values of SSP are less than <50 in post-monsoon 2009-2011and in pre monsoon 2010-2012.

Table 4. Classification of groundwater on the basis of SSP of post-monsoon 2009-2011

	Range	Water Class	Samples	%age
Post-monsoon 2009	<50	Good	50	94.33
	>50	Bad	03	5.66
Post-monsoon 2010	<50	Good	44	83.01
	>50	Bad	09	16.98
Post-monsoon 2011	<50	Good	45	84.90
	>50	Bad	08	15.09

Table 5. Classification of groundwater on the basis of SSP of Pre- monsoon 2010-2012

	Range	Water Class	Samples	%age
Pre-monsoon 2010	<50	Good	46	86.79
	>50	Bad	07	13.20
Pre-monsoon 2011	<50	Good	46	86.79
	>50	Bad	07	13.20
Pre-monsoon 2012	<50	Good	40	81.63
	>50	Bad	08	16.32

Residual Sodium Bicarbonate (RSBC)

Residual Sodium Bicarbonate (RSBC) The Residual Sodium Bicarbonate (RSBC) was calculated according to Gupta and Gupta (1987): RSBC=$HCO_3^-Ca^{2+}$ where, RSBC and the concentration of the constituents are expressed in meq/L. The concentration of bicarbonate and carbonate influences the suitability of water for irrigation purpose. The water with high RSBC has high pH. Therefore, land irrigated with such water becomes infertile owing to deposition of sodium carbonate (Eaton, 1950). The residual sodium bicarbonate values of water samples from the study are in good to doubtful categories as shown in (Table No.5).

Table 6. Classification of groundwater on the basis of RSBC of Post-monsoon 2009-2011

	Range	Water Class	Samples	%age
Post-monsoon 2009	<1.25	Good	09	16.98
	1.25-2.50	Doubtful	18	33.96
	>2.5	Unsuitable	26	49.05
Post-monsoon 2010	<1.25	Good	17	32.07
	1.25-2.50	Doubtful	14	26.41
	>2.5	Unsuitable	22	41.50
Post-monsoon 2011	<1.25	Good	17	32.07
	1.25-2.50	Doubtful	11	20.75
	>2.5	Unsuitable	25	47.16

Table 7. Classification of groundwater on the basis of RSBC of Pre-monsoon 2010-2012

	Range	Water Class	Samples	%age
Pre-monsoon 2010	<1.25	Good	04	07.54
	1.25-2.50	Doubtful	42	79.24
	>2.5	Unsuitable	07	13.20
Pre-monsoon 2011	<1.25	Good	18	33.96
	1.25-2.50	Doubtful	14	26.41
	>2.5	Unsuitable	21	39.62
Pre-monsoon 2012	<1.25	Good	18	36.73
	1.25-2.50	Doubtful	16	32.65
	>2.5	Unsuitable	15	30.61

Maximum samples from post monsoon 2009-2011 and pre-monsoon 2010-2012 shows the falling of RSBC under the class doubtful to unsuitable.

Permeability Index (PI)

The soil permeability is affected by the long-term use of irrigated water and the influencing constituents are the total dissolved solids, sodium bicarbonate and the soil type. In the present study, the permeability index values range between 6.02 to 13.15 and average is 9.66 in post-monsoon 2009. In both the seasons from post-monsoon 2009-2011 and pre-monsoon 2010-2012 shows that all the water samples fall within Class I and ClassII and can be categorized as good irrigation water (Doneen, 1964).

Table 8. Classification of ground water on the basis of Permeability Index from post-monsoon 2009-2011

	Range	Water Class	Samples	%age
Post-monsoon 2009	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-
Post-monsoon 2010	**Range**	**Water Class**	**Samples**	**%age**
	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-
Post-monsoon 2011	**Range**	**Water Class**	**Samples**	**%age**
	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-

Table 9. Classification of ground water on the basis of Permeability Index from pre-monsoon 2010-2012

	Range	Water Class	Samples	%age
Post-monsoon 2009	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-
Post-monsoon 2010	**Range**	**Water Class**	**Samples**	**%age**
	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-
Post-monsoon 2011	**Range**	**Water Class**	**Samples**	**%age**
	<25	Class I (Excellent)	53	100
	25-75	Class II (Good)	-	-
	>75	Class III(Unsuitable	-	-

Kellys Ratio (KR)

The Kellys Ratio was calculated employing the following equation (Kelly, 1963) as $KR=Na/Ca^{2+}+Mg^{2+}$
The kellys Ratio (KR) values of the study area ranged as good class in post-monsoon season from 2009-2011 and in pre-monsoon season 2010-2012 therefore the area is considered as suitable for irrigation purposes.

V. Conclusion

The groundwater quality of Hingoli region, Maharashtra, India was assessed for its irrigational and domestic suitability. The values of average total dissolved solids in study area of post monsoon season 2009-2011 is 1461.11 mg/L and in pre-monsoon season 2010-2011 average value is 1268.93.Both the seasons values of TDS are below the highest desirable limit of WHO and ISI. The average values of all detected physico chemical parameters such as Ca, Mg, TA ($CaCO_3$), Na, K, NO_3, SO_4 are well within the permissible limit. Soluble sodium percentage ,permeability index ,residual sodium bicarbonate and sodium adsorption ratio obtained for most of the water samples were found to be within the safe limits. In addition, most of the other irrigation indices of the sampled water also fall within the permissible level indicating low sodic waters. The groundwater will neither cause salinity hazards nor have an adverse effect on the soil properties and are thus largely suitable for irrigation purpose (G.I. Obiefuna and A. Sheriff,2011).

References

Abdalla, O.A.E., 2009. Groundwater recharge/discharge in semi-arid regions interpreted from Isotope and chloride concentrations. Hydrogeol. J., 3: 679-690.

Apha (american public health association) (1996) standard methods for the examination of water and wastewater, 19th eds. Public health association, washington, dc.

Ayers, R.S., (1977) quality of water for irrigation, j. Irrigation and drainage div., asce, vol. 103, no. Ir2, pp. 135-154.

Ayers, R.S. and D.W. Westcot, 1985. Water quality for agriculture FAO irrigation and drain. Paper No 29(1):1-109. Canter, I.W. and R.C. Knox, 1985. Septic Effects on Ground Water Quality Michigan. Lewis Publishing Inc., pp: 336.

Biswajeet Pradhan and Saied Pirasteh, (2011), Hydro-Chemical Analysis of the Ground Water of the Basaltic Catchments: Upper Bhatsai Region, Maharastra. he Open Hydrology Journal,2011, 5, 51-57

Doneen, L.D., 1964. Notes on water quality in agriculture. Published as a water science and engineering paper 4001, Department of Water Science and Engineering, University of California. Drever, J.I., 1988. The Geochemistry of Natural Water Englewood Cliffs. Prentice Hall, New Jersey, pp: 437.

Eaton, F.M., 1950. Significance of carbonate in Irrigation waters. Soil Sci., 67(3): 128-133.

Gupta, S.K. and I.C. Gupta,1987. Management of Saline Soils and Water. Oxford and IBH Publication Coy, New Delhi, India, pp: 399.

G.I. Obiefuna and A. Sheriff, (2011). Assessment of Shallow Ground Water Quality of Pindiga Gombe Area,Yola Area, NE, Nigeria for Irrigation and Domestic Purposes, Research Journal of Environmental and Earth Sciences 3(2): 131-141, 2011 ISSN: 2041-0492.

Joshi, D.M., A. Kumar and N. Agrawal, 2009. Assessment of the irrigation water quality of River Ganga in Haridwar District India. J. Chem., 2(2): 285-292.

Kelly, W.P., 1963. Use of saline irrigation water. Soil Sci., 95(4): 355-391.NWQS, 2007. Nigeria Water Quality Standard, Nigerian Standard for Drinking Water Quality. SON, pp:14-17.