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Changes in Water Quality of Ground Water, Irrigation Return Flow due to Canal Water and Lithology in Hirakud Command of Orissa, India

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Abstract: The major objectives of the project is to assess lithology of bore wells, impact of canal irrigation water on ground water regimes, water quality of return flow and bore well/plezameters wells and assessment of crop water demand and supply during crop season. The lithological data of 27 bore well/piezometer showed that top layer up to 10 m depth is brown to light brown in colour and crystalline in texture. Beyond this depth it is highly weathered rock, hard rocks and granite and the colour is grey to deep grey. Such type of features resulted in to very low water discharge rate i.e 0.16 to 1.62 l/sec within 35 to 45 m bore well depth. On an average of 27 bore wells, pH of bore well water was 8.25 in pre-monsoon and 8.30 in post monsoon period. Overall the quality of irrigation water was good and was suitable for irrigation as well as domestic use. The concentration of total alkalinity, hardness, calcium, magnesium increased in post monsoon period over pre-monsoon period but reverse was the trend with carbonate concentration. High and positive correlation of pH with carbonate was found. Correlation coefficient of total hardness with calcium, magnesium, chloride was positive and highly significant. Similarly very high correlation of alkalinity with calcium and magnesium indicated higher concentration of its carbonate and bicarbonate salts in ground water.

Key words: Ground water quality, hydrogeology, return flow, canal water, ground water discharge rate

Introduction

The present scenario on growth rate of food production is not sufficient to feed the increasing population in near future. For increasing food production from the existing cultivated area, it is possible only through irrigated agriculture. For this purpose, more area under irrigation is to be brought through surface and ground water. In arid and semi arid region irrigation facilities are created by constructing irrigation projects and sufficient amount of irrigation water is supplied to the crops in irrigation command. But irrigated agriculture in such region contribute heavy salts as well as nitrate (in region of heavy fertilizer application) in ground water and irrigation return flow. Subsequently the man made created bad quality water limits industrial, urban and agriculture use. To avoid any adverse effect of bad quality ground water on human health, European and USA have fixed certain norms and the upper limit for salt and nitrate is 2.8 dS m^{-1} and 50 mg L^{-1}, respectively for EU (European Union, 1998) and 45 mg L^{-1} for nitrate in USA (Tanji and Hanson, 1990). In Western San Joaquin valley of California in USA, Tarbonton *et al*. (2005) worked on salinity appraisal in 89,400 ha area and found that 38% irrigated area is affected due to waterlogging and about 0.5 to 3.3 million ton of salt is accumulated in soil due to evaporation, shallow ground water and semiconfined aquifer. In arid irrigated agriculture, return flow salt loading values ranges from 2 to 20 Mg ha^{-1}/year (Aragues and Tanji, 2003).

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In India about 45% of the total aquifers exploited for irrigation have a water of poor quality. For using such type of ground water for irrigation its suitability is also very important as the water quality depends upon hydro geological environment. In arid and semi-arid region and in coastal region ground water quality is generally not suitable for irrigation due to more salt loads. Still in such areas (Punjab, Haryana and other part of Rajstahan) farmers are using tube well as well as canal water through proper proportion. In Indira Gandhi Nahar Pariyojna (northern region of India) about 7.33% of the canal command area have come in the grip of water logging and soil salinity. In other irrigation command areas (Mula and Jayakwadi in Maharashtra, Chambal and Tawa in Madhya Pradesh, Krishna, Godawari and Nagarjunasagar in Andra Pradesh and Ghatprabha in Karnataka),located in semi-arid region have developed into waterlogged and salt affected soils (Singh, 1996). Hence frequent chemical analysis of ground water and canal water for irrigation is very important for future strategy.

In state of Orissa (Eastern region of India),ground water development is quite low (14.8%) due to receipt of good amount rainfall during wet season (86% of the total annual rainfall of 1503 mm) and low cropping intensity (140%). The quality of groundwater in all part of Orissa is quite satisfactory except in coastal alluvial tract, it is saline. In coastal area of the state, shallow groundwater table is suitable for irrigation but exhaustive exploitation may cause intrusion of bad quality sea water. In western part of Orissa particularly in drouhght-hit districts (Koraput, Bolangir and Bargarh), annual rainfall is comparatively less than the coastal districts and major portion of the aquifer is confined to hard rock which influences quality of ground water and its suitability for domestic, agriculture and industrial use.

In the present investigation, 27 borewells /piezometers were installed during March 2000 in Chaukinala watershed (in western Orissa) in tail end of Baragarh distributaries of Hirakud Irrigation Command. The excess water through surface and sub-surface is going into the Chaukinala i.e., drainage outlets and water quality of borewells/piezometers, canal water and irrigation return flow is monitored to evaluate any changes in water quality parameters. The major objectives of the project is to assess lithology of bore wells, impact of canal irrigation water on ground water regimes, water quality of return flow and bore well/piezometer wells and assessment of crop water demand and supply during crop season.

Materials and Methods

Project Site and Water Quality Analysis

The project was undertaken in Chaukinala watershed (lat. 20°55' to 21°5' and long. 83°4' to 83°50'), a tail end of Baragarh canal system which take off from Hirakud Dam. The canals, Berkerly distributory, Bhimtekra distributory form the catchment boundary of the Chaukinala-a small stream that drains surface runoff during rainy season and part of irrigation return flow to the Mahanadi river. The Mahanadi river also forms a boundary of the study area (Fig. 1). The Bhimtekra distributory with about 25.5 km length and Berkerly distributory system with about 31.0 km length canal system form the study project. The total geographical project area is 28502 ha. The project was started in March 2000 after delineating study area and by installing 27 piezameters/bore wells to a depth of 35 to 45 m. While installing bore well, soil samples from different layers were collected and have analyzed for its various lithological characters. After installation, groundwater from 27 piezameters,irrigation return flow and canal water were collected during pre rainy season (8 to 11 June, 2000) and post rainy season (19 to 24 Novermber, 2000). These samples have been analyzed for pH,TDS, alkalinity, hardness, calcium, magnesium, carbonate, bicarbonate, chlorides during pre and post rainy season. The water pH was measured with digital pH meter. Chloride was estimated by argentiometric method in the form of silver chloride. Total dissolved solid (TDS) was estimated by gravimetric method, alkalinity was determined by volumetric method using sulphuric acid as titrant and pheno-phthalein and methyl

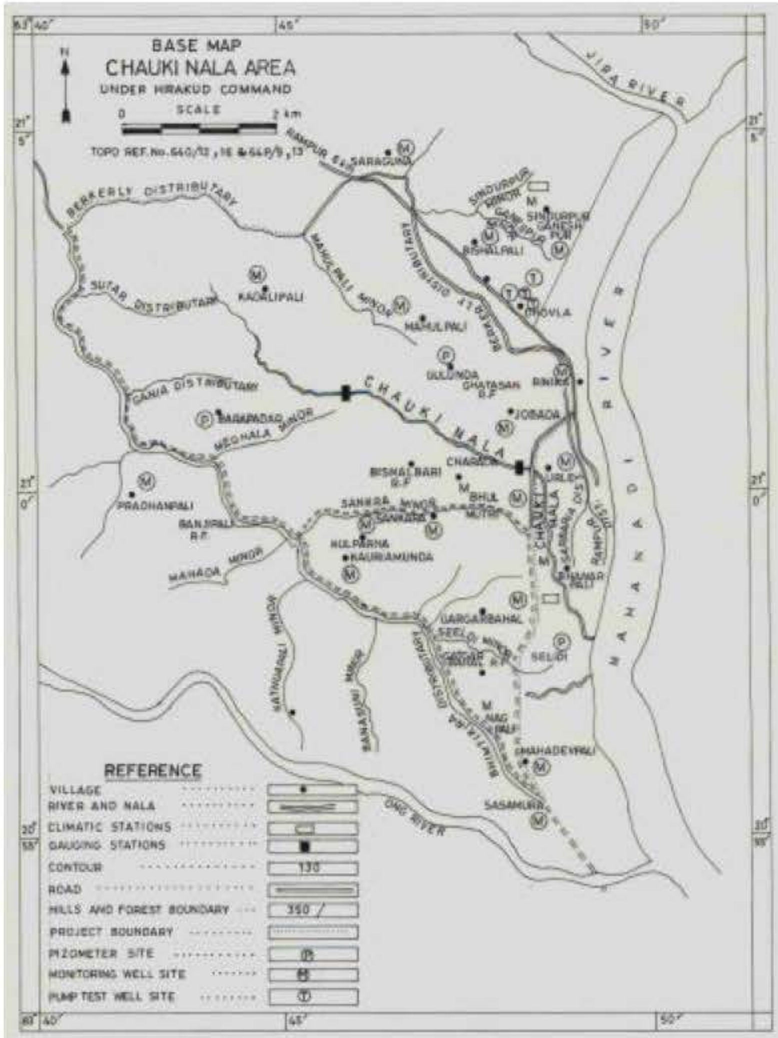

Fig. 1: Chaukinala watershed of Hirakud irrigation project

orange as indicators. Total hardness and calcium was determined by EDTA titrimetric method while magnesium was calculated by deducting calcium from total hardness. The correlation coefficient among different variables have been estimated with standard statistical packages and the correlation coefficients having highly significant ($r>0.8$) have been regressed with pair of variables to make easy assessment of other variables which are not estimated due to lack of facilities with the institutions and the predicted other quality parameters are available within desirable level of precision or not.

Results and Discussion

Lithological Observation

Table 1 revealed that in most of the locations top soils are brown to light brown in colour except in six locations viz., Kulparaha, Barpadar, Mohadavpali, Urle, Sankara, Sasamura, it is light black in color. Below layers are highly weathered rocks and weathered granites. At 35 and 45 m soil depth most

Table 1: Lithological information of borewells under Chaukinala Watershed

Location of borewells	Depth (m)	Rock type	Colour	Texture	Shape
Bhanrapali	15.0	Top soil	Brown	Crystal	Powder
	2.9	Highly Weathered rock	Brown	Crystal	Powder
	35.0	Hard rock	Grey	Crystal	Powder
Binika	8.9	Top Soil	Light Brown	Massive	Powder
	15.7	Weathered Granite	Grey	Crystal	Powder
	35.0	Hard Granite	Grey	Massive	Powder
Bisalpali	7.7	Top soil	Brown	Massive	Powder
	18.9	Weather Granite	Brown	Graphic	Powder
	35.0	Hard Granite	Grey	Graphic	Powder
Berpadar	3.0	Top soil	Light Black	Crystal	Powder
	9.2	Highly weathered rock	Grey	Crystal	Powder
	35.0	Hard Granite	Grey	Crystal	Powder
Charda	15.2	Top soil	Brown	Massive	Powder
	17.0	Weathered granite	Brown	Crystal	Powder
	35.0	Hard Granite	Grey	Crystal	Powder
Dovla-1	5.5	Top soil	L. Brown	Granular	Powder
	8.5	Weathered Granite	Grey	Crystal	Powder
	40.0	Hard granite	Deep Grey	Crystal	Powder
Dovla-II	5.5	Top soil	L. Brown	Granular	Powder
	9.7	Weathered Granite	Grey	Crystal	Powder
	40.0	Hard Granite	Deep Grey	Crystal	Powder
Dovlla-III	5.5	Top soil	L. Brown	Granular	Powder
	9.8	Weathered Granite	Grey	Crystal	Powder
	40.0	Hard Granite	Deep Grey	Crystal	Powder
Dovla-point	5.5	Top soil	L. Brown	Granular	Powder
	11.0	Weathered Granite	Grey	Crystal	Powder
	40.0	Hard Granite	Deep Grey	Crystal	Powder
Gargarbahal	6.5	Top Soil	Brown	Crystal	Powder
	13.7	Weathered Granite	Grey	H.Ophitic	Powder
	35.0	Hard Granite	Grey	H.Ophitic	Powder
Ganeshpur	11.5	Top Soil	L. Brown	M.Crystal	Powder
	18.5	Wheather Granite	L. Brown	M.Crystal	Powder
	45.0	Hard Granite	Grey	Massive	Powder
Gulunda	4.5	Top Soil	L. Brown	Massive	Powder
	13.5	Wheather Granite	Grey	Massive	Powder
	35.0	Hard Granite	Grey	Granular	Powder
Jobda	9.8	Top soil	Brown	Crystal	Powder
	18.5	Weather Granite	Brown	Massive	Powder
	45.0	Hard Granite	Grey	Massive	Powder
Kulparaha	10.4	Top soil	L. Black	Massive	Powder
	22.5	H.Weathered rock	Grey	Crystal	Powder
	45.0	Hard Granite	Grey	Crystal	Powder
Kauriamunda	8.3	Top soil	Brown	Crystal	Powder
	19.5	H.weathered rock	Grey	Massive	Powder
Kadalipali	5.3	Top soil	Brown	Massive	Powder
	13.5	Weathered Granite	Grey	Crystal	Powder
	45.0	Hard Granite	Grey	Crystal	Powder
Mohadavpali	10.7	Top soil	L. Black	Massive	Powder
	12.0	Hard rock	Light Grey	Graphic	Powder
	23.0	Weathered Granite	Light Grey	M.c rystal	Powder
	35.0	Hard Granite	Light Grey	Graphic	Powder
Mahulpali	9.3	Top soil	Brown	Massive	Powder
	16.5	Weathered Granite	Brown	Graphic	Powder
	40.0	Hard Granite	Grey	Graphic	Powder
Nagpali	8.0	Top soil	L. Brown	Granular	Powder
	20.1	Weathered Granite	Grey	Massive	Powder
	35.0	Hard Granite	Grey	Massive	Powder
Phulmuthi	7.5	Top soil	L. Brown	Massive	Powder
	18.4	Weathered Granite	L. Brown	Crystal	Powder
	23.7	H.Weathered rock	L.Brown	Crystal	Powder
	35.0	Hard Granite	Grey	M.Crystal	Powder

Table 1: Continued

Location of borewells	Depth (m)	Rock type	Colour	Texture	Shape
Pradhanpali	9.3	Top soil	Brown	Massive	Powder
	14.7	Weathered Granite	Grey	M. Crystal	Powder
	40.0	Hard Granite	Grey	Crystal	Powder
Sasamura	5.0	Top soil	L. Black	Crystal	
	7.9	Weathered Granite	Grey	H.Ophitic	Powder
	35.0	Hard Granite	G. White	H.Ophitic	Powder
Sarguna	6.5	Top soil	Brown	Crystal	Powder
	16.5	H/ Weathered rock	Brown	Crystal	Powder
	35.0	Hard Granite	Grey	Crystal	Powder
Selidi	14.0	Top soil	L. Brown	Massive	Powder
	25.7	Weathered Granite	Grey	Crystal	Powder
	35.0	Hard rock	Grey	M.Crystal	Powder
Sindurpur	6.9	Top soil	Brown	Massive	
		H. Weathered rock	Brown	M. Crystal	Powder
		Hard Granite	Grey	Crystal	Powder
Sankara	9.5	Top soil	L. Black	Crystal	Powder
	24.3	H. Weathered rock	Grey	Crystal	Powder
	35.0	Hard Granite	Grey	Granular	Powder
Urle	7.8	Top soil	L. Black	Crystal	Powder
	12.1	H. Weathered rock	Grey	Granular	Powder
	35.0	Hard Granite	Grey	Granular	Powder

of the places has hard rock and hard granites. These types of rocks are not water bearing strata. Hydrogeology of the district Bolangir have been studied in details by many worker (Basak, 1977; Kar, 1997) and found that major part of the districts are occupied by hard and compact crystalline rocks which lacks porosity. Such type of lithological features of aquifer up to 45 m soil depth results into frequent fluctuatiion of water level during rainy season and then sudden drop after monsoon season. Further, Central Ground Water Board, South Eastern Region, Bhubaneswar, Orissa prepared a comprehensive report on conjuctive use of surface and ground water resources in Hirakud irrigation project during 1998 and made certain remark that in total CCA of 1.57 lakh ha area of Hirakud command with irrigation intensity of 170% (100% in kharif and 70% in rabi), granite and granite gneisses are the major rocks occupying more than 90% of the total geographical area of the command. These rocks are generally hard and are devoid of porosity.

Depending upon the texture, structure and porosity of the weathered rocks, the water yielding capacity of the bore differed. The data on discharge rate of 27 bore wells which were installed during 10 to 27 March 2000 in soil depth of 35 to 45 m varied from 0.38 l/sec to 1.63 l/sec which is quite low (Table 2). This low water yielding capacity of the bore well is not acceptable by Government of Orissa and NABARD for funding to the farmers for installing shallow tube wells as minimum discharge rate for awarding loan should be 2.0 l/sec. Central Ground Water Board, Bhubaneswar (Anonyumous, 1998) has made 28 exploratory and 4 observation wells up to 200 m depth in whole Hirakud command and observed that the discharge rate of these wells are ranging from 0.88 to 4 l/sec. In some of the undulating granite terrains bore well made up to 100 m depth yielded 5 l/sec which is quite useful for ground water development. In the irrigation command particularly the tail reach farmers are not getting sufficient amount of canal water in proper time like head reach farmers. So, exploiting ground water through deep tube well is highly essential for which attention for immediate implementation of the ground water development project is required.

Water Quality of Project Area

The quality of ground water depends upon the nature of geological formation. physiographic features and climatic conditions of the area. The quality of the water sample collected from 27 bore wells during pre monsoon season of June 2000, showed that the ground water is neutral to alkaline in reaction and the pH varied from 7.0 to 9.0 with standard deviation of 0.351 (Table 3). Out of 27 bore

Table 2: Details of observation bore wells in Chaukinala water shed installed during March 2000

Name of the village	Date of installation March 2000	Depth (m)	Discharge (l/sec)
Bhanarpali	15	35.0	0.85
Binika	16	35.0	0.85
Bisalpali	19	35.0	0.38
Barpadar	23	35.0	0.85
Charada	14	35.0	0.16
Dolva-I	16	40.0	1.63
Dolva-II	17	40.0	1.63
Dolva-III	17	40.4	1.63
Dolva-PT	28	40.0	1.63
Gargarbahal	12	35.0	0.16
Ganeshpur	18	45.0	0.16
Gulunda	12	35.0	0.38
Jobada	22	45.0	0.38
Kulparha	13	45.0	0.85
Kauriamunda	14	41.0	0.85
Kedalipali	20	45.0	0.85
Mahadevpur	10	35.0	0.16
Mahulpali	20	40.0	0,38
Nagpali	11	35.0	0.38
Phulmuthi	12	35.0	0.85
Pradhanpara	24	40.0	0.06
Sasamura	10	35.0	0.85
Sarguna	19	35.0	0.85
Selidi	11	35.0	0.85
Sindurpur	18	35.0	0.85
Sankar	13	35.0	1.63
Urle	15	35.0	0.85

Mean = 0.78 l/sec

Table 3: Hydrochemical data of ground water, canal water and irrigation return flow during 6-10 June 2000

Parameters	Ranges	Mean	Standard deviation
pH	7.0-9.0	8.25	0.351
	(7.0-9.0)	(8.30)	(0.46)
TDS (mg L^{-1})	258.0-771	528.67	166.76
	(-)	(-)	(-)
Total alkalinity	72-348	173.04	66.0
(mg L^{-1})	(68-364)	(181-42)	(106-13)
Total hardness	40-184	93.26	38.53
(mg L^{-1})	(60-328	(171.36)	(78.84)
Calcium	11.2-41.6	19.06	8.00
(mg L^{-1})	(107.6-90.0)	(42.28)	(23.78)
Magnesium	2.88-36.48	10.06	6.59
(mg L^{-1})	(1.92-36.80)	(15.88)	(10.14)
Carbonate	0.00-38.4	19.47	9.23
(mg L^{-1})	(0.00-28.8)	(8.0)	(11.81)
Bicarbonate	87.84-375.76	190.93	68.50
(mg^{-1})	(-)	(-)	(-)
Chloride	11.34-113.44	37.36	31.98
(mg L^{-1})	(-)	(-)	(-)

Figures in bracket are values of November 19-24, 2000. In November 2000,TDS, Bicarbonate and chlorides were not analyzed

wells water of 20 bore wells had pH more than 8.0 and rest had pH between 7.0 and 7.9. In the post monsoon period i.e in the month of November, 2000 there was no change of ground water pH however the pH of canal water irrigation return flow was slightly higher i.e 7.4 and 9.0, respectively as compared to the values recorded in June 2000. In later case, seepage and subsurface flow of canal water has higher pH due to dissolved chemical constituents, flowing in the drainage nala. In case of total dissolved solids, in 14 bore wells the values were in safe limit for domestic use and it ranged from 258.0 to 487.5 mg L^{-1} but in remaining 13 bore wells the TDS value was ranging from 518.0 to 869.5 mg L^{-1}

which exceeded the permissible limit of 500 mg L^{-1} (World Health Organisation). The higher value of TDS in these bore wells could be due to higher mineralization rate of the minerals available in aquifers. Total hardness as $CaCO_3$ of the water sample were also quite low during pre monsoon period and ranged between 40-189 mg L^{-1} which were quite safe for domestic use but in November 2000 total hardness as $CaCO_3$ increased to 60-328 mg L^{-1} in two bore wells the total hardness as $CaCO_3$ was greater than 300 mg L^{-1} which exceeded the permissible limit for consumption. Calcium concentration in water during pre monsoon was quite safe under permissible limit of 75 mg L^{-1}. However in post monsoon period, calcium concentration was above 75 mg L^{-1} in four bore wells with maximum of 90 mg L^{-1}. With regard to magnesium concentration, in one of the bore well it was 36.48 mg L^{-1} during pre monsoon and in two bore wells it was 36.48 to 36.80 mg L^{-1} during post monsoon period which can not be used for drinking purpose as it exceeded the permissible limit of 30 mg L^{-1}. In canal water magnesium concentration was 4.8 to 8.64 mg L^{-1} but in irrigation return flow it was as high as 10.56 mg L^{-1}. Higher amount of magnesium in irrigation return flow might be due to movement of magnesium salt available in the soil profile along with seepage and subsurface flow.

Carbonate in groundwater during pre monsoon period was present in 18 locations with concentration ranging from 9.6 to 38.4 mg L^{-1} and in rest seven locations it was nil but during post monsoon period, carbonate was available in 16 locations with values ranging from 19.6 to 24.0 mg L^{-1}. In canal and irrigation return flow it was 9.6 and 14.4 mg L^{-1}, respectively. Bicarbonate was available at the tune of 87.84 to 375.76 mg L^{-1}. During post monsoon period bicarbonate concentration generally increases as microbial organism produces CO_2 in the process of respiration. But in pre monsoon season roots activities and microbial activities are slightly ceases due to non availability of adequate soil moisture in profile and decaying of roots. During post monsoon period, the bicarbonate and chlorides was not estimated. Chloride concentration during post monsoon period was recorded to be 11.34 to 113.44 mg L^{-1}. The concentration of different salts in ground water of this region is not harmful to the crops if the ground water is made available to the farmer in un-command area. Central Ground Water Board, Bhubaneswar (Anonymous, 1998) collected water sample from 17 deep bore wells having total depth from 100.5 to 200 m and found that SAR value is ranging from 0.9 to 2.2 m mole $L^{-1})^{1/2}$. In shallow bore wells the SAR value was in the range of 0.68 to 4.05 m mole $L^{-1})^{1/2}$ and majority of water sample (56.25%) were in the category of C_2S_1 as per USSL classification which can be considered as good quality water. Chowdary *et al*. (2005) studied ground water quality of Godavari Delta Central Canal Irrigation Project in East Godavari district of Andhra Pradesh, India in total command area of 84, 000 ha. Rice is main crop grown during rainy season and it is fertilized with 120 kg N ha^{-1}. They monitored nitrate nitrogen in ground water and the concentration was recorded to the tune of 20-50 ppm which may further increase if rice is grown continuously. They suggested to take alternate crop in this command area. Similar results have been reported by Ozha *et al*. (1993) and Vijay Kumar *et al*. (1993) in different irrigation command in India where rice has been intensively cultivated during both rainy and winter season. In Philippines (at Magnuang, Bata, Ilocos Norte) Gumtang *et al*. (1999) assessed ground water dynamics and water quality during October, 1994 to March, 1996 (wet and dry season) in 19 selected wells of 265 ha area. They found that in all observation wells electrical conductivity (700-3000 microhos cm^{-1}) and HCO_3^- (90-500 ppm) exceeded FAO threshold quality of irrigation water. Electrical conductivity(EC) increased at the start of wet season and lower concentration was observed in wet season due to dilution effect. However the level of Cl^- and pH were in safe limit except in one open well. With regards to NO_3-N, eight wells showed near or above the World Health Organisation NO_3-N limits(10 ppm) for drinking water. This was due to application of high amount of nitrogenous fertiliser (120 kg N ha^{-1}) in rice during wet season and 340 kg N ha^{-1} during dry season in other upland crops.

The correlation coefficient of pH with TDS, alkalinity, hardness and bicarbonate was significant (Table 4), however the relationship between pH and carbonate was highly significant ($r = 0.80$). Total

Table 4: Correlation coefficients between different hydrochemical parameters

Parameters	pH	TDS (mg L^{-1})	Alkalinity	Hardness	Calcium	Magnesium	Carbonate	Bicarbonate	Chloride
pH	(-)	0.64	0.55	0.38	0.20	0.32	0.31	0.47	0.26
		(0.33)	(0.0016)	(-0.26)	(-0.057)	(0.80)			
TDS(mg L^{-1})	0.64	-	0.96	0.56	0.42	0.63	0.39	0.89	0.51
Total alkanity	0.55	0.96	-	0.49	0.48	0.34	0.58	0.96	0.12
(mg L^{-1})	(0.35)	-	-	(0.75)	(0.88)	(0.63)	(0.78)	-	-
Total hafdness	0.38	0.56	0.49	-	0.61	0.86	0.58	0.53	0.82
(mg L^{-1})	(0.0016)	-	(0.75)	-	(0.77)	(0.88)	(0.36)	-	-
Calcium	0.20	0.41	0.48	0.61	-	0.18	0.70	0.40	0.58
(mg L^{-1})	(0.26)	-	(0.80)	(0.76)	-	(0.71)	(0.18)	-	-
Magnesium	0.32	0.63	0.34	0.86	0.18	-	0.36	0.64	0.69
(mg L^{-1})	(0.057)	-	(0.63)	(0.88)	(0.30)	-	(0.34)	-	-
Carbonate	0.31	0.39	0.58	0.58	-	0.36	-	0.44	0.37
(mg L^{-1})	(0.80)	-	(0.73)	(0.36)	-	(0.34)	-	-	-
Bicarbonate (mg L^{-1})	0.47	0.89	0.96	0.53	0.40	0.64	0.44	-	0.09
Chloride (mg L^{-1})	0.26	0.50	0.12	0.82	0.58	0.69	0.37	0.09	-

Figures in parenthesis are values of NOV. 2000

Table 5: Regression equation for various hydrochemical parameters (June 2000)

Parameters	Equation		R^2	F-ratio	T-ratio
TDS	-1160.44	+200.99 pH	0.273	9.416	3.068
	(539.02)	(65.49)			
Alkalinity	-532.720	+85.874 pH	0.321	11.855	3.443
	(205.252)	(24.94)			
Hardness	-184.482	+33.794 pH	0.147	4.332	2.081
	(133,61)	(16.235)			
Calcium	-16.879	+4.460 pH	0.066	1.785	1.336
	(27.47)	(3.338)			
Magnesium	-30.912	+4985 pH	0.108	3.046	1.745
	(23.50)	(2.856)			
Carbonate	-144.699	+19.185 pH	0.488	23.862	4.884
	(32.32)	(3.92)			
Bicarbonate	-388.008	+70.236 pH	0.209	6.626	2.574
	(224.54)	(27.284)			
Chloride	-60.135	+11.752 pH	0.030	0.777	0.881
	(109.696)	(13.329)			
Alkalinity	-380.755	+67.703 pH	0.12	3.75	1.937
	(290.535)	(34.937)			
Hardness	173.606'	-0.270 pH	0.0000248	0.00644	-0.83
	(0.618)	(0.337)			
Calcium	80.24	-4.28 pH	0.0096	0.25	-0.50
	(70.66)	(8.49)			

Table t at 25 and 26 degree of freedom at 5% level of significance is 2.060 and 2.056, respectively Figure in brackets are standard error

Table 6: Regression of highly significant (r =>0.80) hydrochemical parameters June 2000

Parameters	Equation		R^2	F-ratio	T-stat
June 2000					
Alkalinity	+7.417	+0.337 TDS	0.731	68.131	8.254
	(21.157)	(0.040)			
Carbonate	+9.030	+0.366TDS	0.843	134.563	11.600
	(16.380)	(0.031)			
Bicarbonate	+26.040	+0.943 alkalinity	0.866	161.690	12.715
	(1.770)	(0.017)			
Chloride	-19.887	+0.604 hardness	0.616	40.112	6.333
	(9.591)	(0.095)			
Nov.2000					
Calcium	+19.093	+0.141 alkalinity	0.381	16.044	4.005
	(7.069)	(0.035)			
Magnesium	-3.437	+0.112 hardness	0.768	86.302	9.289
	(2.282)	(0.012)			

Figure in parentheses are standard error dissolved solids with total alkalinity and bicarbonate was strongly and positively correlated. Total alkalinity of ground water was dominated with carbonate and bicarbonate of calcium, however it was not strongly correlated with hardness, calcium and carbonate. Total hardness was stroungly and positively correlated with mangesium and chlorides, which indicated higher concentration of these salts. In ground water calcium chloride and calcium carbonate salts is present in adequate quantity and highly correlated with total hardness. Jain and Sharma (2002) have developed systematic correlation of ground water sample of Malprabha basin and found that electrical conductivity (EC) and total alkalinity, total hardness, chloride, sulphate, nitrate, sodium, calcium and magnesium is highly correlated.

Considering pH as independent variable and all other parameters as dependent variables to evaluate water quality parameters if only pH of water is estimated since in all locations estimation of all water quality parameters at the site is not possible due to several constraints and then developed the regression equation. The results presented in Table 5 and 6 show that in pre monsoon period an approximate prediction of carbonate in ground water through observed water pH is possible to some extent as the coefficient of determination is higher and the ' t ' ratio is also significant, but for rest of parameters prediction through water pH is not acceptable in this selected site. However, Krishna *et al*. (1995); Singanan *et al*. (1995) Balasankar and Nagrajan (2000) have widely used the regression equation for estimating concentration of several ground water quality parameters.

References

Anonymous, 1998. Studies on conjunctive use of surface and ground water resources in Hirakud Irrigation Project. Central Ground Water Board. South Eastern Region, Bhubaneswar, pp: 1-293.

Aragues, R. and K.K. Tanji, 2003. Water Quality of Irrigation Return Flow. Encyclopodia of Water Science, Marcel Dekker Inc., pp: 502-506.

Balasankar, T. and S. Nagrajan, 2000. A correlation study on physico-chemical characteristics of ground water in and around Cuddalore Sipcot., Tamilnadu. Ind. J. Environ. Prot., 20: 427-429.

Basak, B.B., 1977. Reappraisal hydrology surveys in part of Bolangir district in Tel sub-basin, Mahanadi basin, Orissa. Central Ground Water Board Bhubaneswar Report.

Chowdary, V.M., N.H. Rao and P.B.S. Sarma, 2005. Decision support frame work for assessment of non point source pollution of ground water in large irrigation project. Agri. Water Manage., 75: 194-225.

European Union, 1998. Council directives 98/83/CE of 3 November, 1998 imposed to the surface water devoted to the production of water for human consumption. Off. J. L., 330: 32-54.

Gumtang, R.J., M.F. Pampolino, T.P. Tuong and D. Bucao, 1999. Ground water dynamics and quality under intensive cropping system. Expl. Agric., 35: 153-166.

Jain, C.K. and M.K. Sharma, 2002. Regression analysis of ground water quality data of Malprabha river basin, Karnataka. J. Ind. Water Res. Society, 22: 30-35.

Kar, A., 1997. Ground water resource and development potential of Bolangir District. Orissa Central Ground Water Board, Bhubaneswar Report.

Krishna, J.S.R., K. Rambabu and C. Rambabu, 1995. Monitoring correlation and water quality index of well water of Reddiguden mandal. Indian J. Environ. Prot., 15: 914-919.

Ozha, D.D., C.P. Warshney and J.L. Bohra, 1993. Nitrate in groundwater of some districts of Rajsthan, India. Ind. J. Environ. Health, 35: 15-19.

Singh, S.R. 1996. Need for conjunctive use in canal command. J Water Manage., 4: 28-30.

Singanan, M., K.S. Rao and C. Rambabu, 1995. A Correlation study on physico- chemical characteristics of ground water in Rameswaram Island. Ind. J. Environ. Prot. 15: 212-217.

Tanji, K.K. and B.R. Hanson, 1990. Drainage and Return Flow in Relation to Irrigation Management. In: Irrigation of Agricutural Crops. Stewart, B.A., D.R. Neilson, (Eds.). Am. Soc. Agron., Madison, WI, USA (chapter 35), pp: 1057-1088.

Tarbonton, K.C., W.W. Wallender and N.S. Raghuwanshi, 2005. Farm salinityappraisal with water reuse. Irrig. Drain. Sys., 18: 255-273.

Vijay Kumar, V., C.S.T. Sai, M.S.R. Swami and P.L.K.M. Rao, 1993. Nitrate inground water source in Medchal block in Andhra Pradesh. Indian Environ. Health, 35: 40-46.