Assessment of Pollution in Ground Water in Krishna Delta

R. Venkata Ramana

Abstract: ***The maintenance of groundwater quality is more necessary due to increasing demand and need for various purposes such as drinking and cultivation of crops etc. Over-exploitation without proper planning decreases groundwater quality which affects adversely the health aspects of living beings and decrease in agricultural output.. Hence a detailed survey conducted for examine groundwater pollution in Doppalapudi (Latitude: 15.9741^0 N; Longitude: 80.5070^0 E) and Mannava (Latitude: 16.4810^0 N; Longitude: 80.5787^0 E) regions. The formations in the study area belong to sand and clay of Recent Era. Groundwater is analyzed for various physico-chemical parameters. Most of these parameters values are excess over prescribed values for drinking water. Values of quality methods such as Percent Sodium etc., suggest groundwater not suited to cultivation. Present attempt is made to examine the various controlling factors. This study is useful for similar studies throughout the world. Appropriate remedial measures are suggested for development of ground water quality to maintain environmental balance in study area.***

IndexTerms: ***Mannava, Doppalapudi, Percent Sodium method.***

I. INTRODUCTION

Groundwater usage and its dependency is increasing tremendously in Andhra Pradesh, Groundwater is extensively utilized to cultivate crops such as rice etc., as limited amount of canal water available in this area. More agricultural chemicals utilize and exploitation of groundwater without proper planning deteriorates the quality of groundwater in many river basins in the country [1,2,3, 5,6,7,8]. Previous studies conducted in this area are on physicochemical changes of groundwater [4,9], and effect of climatic changes on groundwater quality [10]. Literature indicates that less effort made upto this time [4,9,10,12]. Administrators can plan and to be maintained and monitor the groundwater quality in this area after knowing various geochemical processes responsible for deterioration of groundwater quality.

A *Study Area*

It is situated 14 km away from Ponnur in the north direction and lies in between Eastern longitudes 80.5070^0 and 80.5787° and Northern latitudes 15.9741° and 16.4810° as shown in map enclosed (Fig 1). The Doppalapudi and Mannava villages are situated in the western delta of Krishna River.

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II. PHYSIOGRAPHY

It has gentle slope towards the Bay of Bengal. It has scattered drainage pattern which developed as irrigation channels and drains. It has more than 90% agricultural land.

A *Hydrogeology*

The area contains sand and clay of Recent era [17]. The sandy soils comprises of coarse permeable to medium sands in and around the villages of Doppalapudi and Mannava. The area has clayey formations upto a depth of 12m below the soil zone of 2 to 3m. The clayey formations contain brackish ground water. Sandy deposits are permeable and extend down to a depth range of 12 to 32 m., beneath thick clay, Fresh groundwater occurs in sandy aquifer. Rainwater and canal water are the major recharge sources of ground water. Groundwater is extracted by means of shallow filter points for irrigation purpose. Water table depth varies from 6.4 to 26 m below ground level.

III. QUALITY STUDIES

Hydrogeological investigations conducted in Doppalapudi and Mannava areas indicate that the pollution in groundwater has increased significantly at present. Hence to examine this, 4 samples of groundwater from each village in various directions were collected during the sampling period to find the concerned factors leading to salinization in the aquifer [12,15]. Physicochemical parameters values such as calcium (Ca), magnesium (Mg) etc. are determined by following the methods according to the manual of American Public Health Association (APHA) [14]. The data of groundwater samples in 1976 year [18], and in 2018 year is analyzed for comparison. The data is presented in the table as follows:

Table 1: Showing the analysis of ground water samples in Doppalapudi and Mannava regions

Chemical Parameter	A – Doppalapudi Village				
	1976	Pre monsoon 2018			
P^H	7.56	9.10	9.18	9.14	9.15
EC (µs/cm)	1.84	2.55	2.59	2.66	2.64
CO_3^{2-} (meq/l)	0.86	3.98	4.22	3.94	3.87

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HCO_3^- "	6.78	2.63	2.51	2.53	2.46
Cl^- "	8.36	17.52	17.64	17.48	17.59
SO_4^{2-} "	0.52	5.59	5.76	5.73	5.76
Ca^{2+} "	4.45	1.54	1.68	1.56	1.48
Mg^{2+} "	4.05	1.83	1.73	1.69	1.78
Na^+ "	7.80	38.57	38.48	38.33	38.44
K^+ "	0.18	0.53	0.56	0.52	0.59
Ratio (Cl^- / HCO_3^-)	0.85	6.66	7.03	6.91	7.15
RSC (meq/l)	1.14	3.24	3.12	3.22	3.07
SAR "	3.78	29.72	29.49	30.06	30.10
SSP "	47.85	91.96	91.86	92.18	92.17
%Na "	47.33	90.82	90.65	91.05	90.90
KR "	0.92	11.45	11.28	11.79	11.79
MR "	47.64	54.30	50.73	52.00	54.60

Chemical Parameter	A – Doppalapudi Village				
	1976	Post monsoon 2018			
P^H	7.56	8.86	8.91	8.97	8.94
EC (µs/cm)	1.84	2.63	2.69	2.72	2.70
CO_3^{2-} (meq/l)	0.86	3.49	3.55	3.74	3.67
HCO_3^- "	6.78	2.46	2.41	2.45	2.49
Cl^- "	8.36	18.51	18.48	18.44	18.47
SO_4^{2-} "	0.52	7.89	7.76	7.73	7.78
Ca^{2+} "	4.45	1.10	1.14	1.16	1.22
Mg^{2+} "	4.05	1.76	1.60	1.70	1.68
Na^+ "	7.80	35.34	35.62	35.57	35.71
K^+ "	0.18	0.45	0.46	0.42	0.49
Ratio (Cl^- / HCO_3^-)	0.85	7.52	7.67	7.53	7.42
RSC "	1.14	3.09	3.22	3.33	3.26
SAR "	3.78	29.55	30.43	29.74	29.

					66
SSP "	47.85	92.51	92.86	92.56	92.49
%Na "	47.33	91.44	91.76	91.56	91.33
KR "	0.92	12.36	13.00	12.44	12.31
MR "	47.64	61.54	58.39	59.44	57.93

Chemical Parameter	B – Mannava Village				
	1976	Pre monsoon 2018			
P^H	7.48	8.97	9.08	9.06	9.11
EC (µs/cm)	1.44	2.72	2.78	2.77	2.73
CO_3^{2-} (meq/l)	0.48	3.53	3.57	3.44	3.63
HCO_3^- "	8.05	2.69	2.66	2.63	2.68
Cl^- "	5.22	16.42	16.67	16.43	16.56
SO_4^{2-} "	3.30	7.38	7.46	7.43	7.48
Ca^{2+} "	3.93	1.25	1.29	1.32	1.44
Mg^{2+} "	3.88	1.74	1.79	1.58	1.66
Na^+ "	7.16	36.38	36.88	36.81	36.87
K^+ "	0.12	0.66	0.69	0.65	0.67
Ratio (Cl^- / HCO_3^-)	0.65	6.11	6.27	6.25	6.18
RSC "	0.67	3.23	3.15	3.17	3.21
SAR "	3.62	29.77	29.72	30.57	29.62
SSP "	47.83	92.41	92.29	92.70	92.24
%Na "	47.45	90.88	90.73	91.20	90.72
KR "	0.92	12.17	11.97	12.69	11.89
MR "	49.68	58.19	58.12	54.48	53.54

Chemical Parameter	B – Mannava Village				
	1976	Post monsoon 2018			
P^H	7.48	9,24	9.16	9.12	9.19
EC (µs/cm)	1.44	2.81	2.74	2.69	2.73
CO_3^{2-} (meq/l)	0.48	3.58	3.62	3.49	3.66

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HCO_3^- "	8.05	2.85	2.76	2.78	2.75
Cl^- "	5.22	18.83	18.87	18.73	18.78
SO_4^{2-} "	3.30	7.04	7.16	7.13	7.08
Ca^{2+} "	3.93	1.48	1.43	1.39	1.44
Mg^{2+} "	3.88	1.61	1.53	1.65	1.59
Na^+ "	7.16	37.55	37.68	37.73	37.87
K^+ "	0.12	0.38	0.46	0.43	0.41
Ratio (Cl^- / HCO_3^-)	0.65	6.61	6.84	6.74	6.83
RSC (meq/l)	0.67	3.34	3.42	3.33	3.38
SAR "	3.62	30.21	30.97	30.61	30.77
SSP "	47.83	92.39	92.72	92.61	92.59
%Na "	47.45	91.54	91.67	91.58	91.67
KR "	0.92	12.15	12.73	12.41	12.50
MR "	49.68	52.10	51.69	54.28	52.48

Table 2: Bureau of Indian Standards (BIS) values for the methods Percent Sodium etc., are as follows:

Parameter	Range	Category
SAR	<10 10-18 18-26 >26	Excellent Good Fair Unsuitable
RSC	<1.25 1.25-2.5 >2.5	Safe Suitable Unsuitable
SSP	<50 >50	Good Unsuitable
%Na	<20 20 - 40 40 - 60 60 – 80 >80	Excellent Good Permissible Doubtful Unsuitable
KR	<1 >1	Good Unsuitable
MR	<50 >50	Suitable Unsuitable

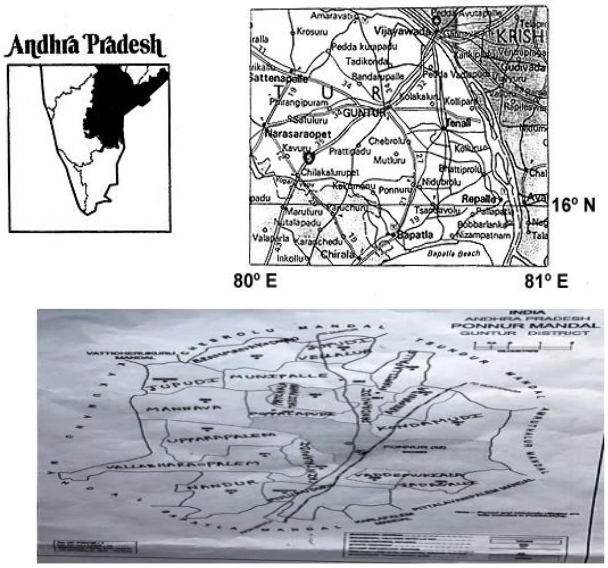

Figure 1: Location Map of Doppalapudi and Mannava Villages of Ponnur Mandal of Guntur District.

A *Sodium Absorption Ratio (SAR)*

Risk of salinity is indicated by Sodium absorption ratio. SAR reveals that the groundwater can be used for cultivation or not. SAR value is determined as follows:

$$\text{Sodium Absorption Ratio} = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

SAR value 3.78 in Doppalapudi and 3.62 in Mannava villages in the year 1976 from Table 1 suggest its suitability for agriculture purpose during that period. SAR values range from 29.49 to 30.43 in 2018 year in Doppalapudi and range from 29.62 to 30.97 in 2018 year in Mannava villages from Table 1 suggest its unsuitability for agriculture purpose.as per Table 2.

B *Residual Sodium Carbonate (RSC)*

Residual Sodium Carbonate (RSC) indicates the alkalinity content remain in the groundwater sample. RSC is determined as follows:

Residual Sodium Carbonate = $(HCO_3 + CO_3) – (Ca + Mg)$

Excess in permissible limits of Residual sodium carbonate affects irrigation adversely [16]. Use of such waters contains high RSC values increase the risk of salinity in the area. RSC value is 1.14 in Doppalapudi and 0.67 in Mannava villages in the year 1976 from Table1 suggest its suitability for agriculture purpose during that period. RSC values range from 3.07 to 3.33 in 2018 year in Doppalapudi and range from 3.15 to 3.42 in 2018 year in Mannava villages from Table1 suggest its unsuitability for agriculture purpose as per Table 2.

C *Soluble Sodium Percent (SSP)*

Calcium is replaced by Sodium in ion exchange process. This increase in sodium content in the soil increases impermeability of soil. Soluble Sodium Percent (SSP) is determined as follows:

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$$SSP = \frac{Na\ X\ 100}{Ca+Mg+Na}$$.

SSP value is 47.85 in Doppalapudi and 47.83 in Mannava villages in the year 1976 from Table 1 suggest its suitability for agriculture purpose during that period. SSP values range from 91.86 to 92.56 in 2018 year in Doppalapudi village and range from 92.24 to 92.72 in 2018 year in Mannava village from Table 1 suggest its unsuitability for agriculture purpose as per Table 2.

D *Sodium Percent (%Na)*

Sodium percent value indicates whether groundwater can be used for agriculture purpose or not [19]. Sodium combining with carbonate or chloride forms either alkaline or saline soils respectively. These soils reduce yield of crops. Sodium percent (Na%) is determined as follows:

$$\text{Sodium percent} = \left[\frac{Na}{Ca + Mg + Na + K}\right] X100$$

Sodium percent value is 47.33 in Doppalapudi and 47.45 in Mannava villages in the year 1976 from Table1 suggest its suitability for agriculture purpose during that period. %Na values range from 90.65 to 91.76 in 2018 year in Doppalapudi and range from 90.72 to 91.67 in 2018 year in Mannava villages from Table1 suggest its unsuitability for agriculture purpose as per Table 2.

E *Kelly's Ratio (KR)*

Depending on Kelly's ratio, irrigation waters can be classified. Excess Na in water changes soil properties and reduces soil permeability. Kelly's ratio (KR) indicates alkali hazard in water [20]. KR is determined as follows:

$$KR = \frac{Na}{Ca+Mg}$$

KR value is 0.92 in Doppalapudi and Mannava villages in the year 1976 from Table 1 suggest its suitability for agriculture purpose during that period. KR values range from 11.28 to 13.00 in 2018 year in Doppalapudi and range from 11.89 to 12.73 in 2018 year in Mannava villages from Table1 suggest its unsuitability for agriculture purpose as per Table 2.

F *Magnesium Ratio (MR)*

It represents more magnesium content than calcium and magnesium. This more magnesium content leads to less crop yield. Magnesium Ratio (MR) is determined as follows:

$$\text{Magnesium Ratio} = \frac{Mg\ X\ 100}{Ca+Mg}$$

Magnesium Ratio value is 49.47 in Doppalapudi and 49.68 in Mannava villages in the year 1976 from Table 1 suggest its suitability for agriculture purpose during that period. MR values range from 50.73 to 61.54 in 2018 year in Doppalapudi and range from 51.69 to 58.19 in 2018 year in Mannava villages from Table 1 suggest its unsuitability for agriculture purpose as per Table2.

Groundwater from the filter points of study area is utilized for drinking and irrigation use. Pollution in groundwater in the area may be due to increasing in groundwater development through filter points and more inputs of agricultural chemicals. The filter points raised to 1228 in Doppalapudi and 1092 in Mannava areas at present. The study indicates unsuitability for drinking and agriculture use. It attributes to more precipitation of ions such as magnesium etc. This is due to higher concentration of parameters such as Ca, This more precipitation causes raise in electrical conductivity values which ultimately leads to decrease in soil quality. The rise in electrical conductivity values suggests groundwater pollution. It may be due to excess exploitation of groundwater, the returns of agricultural sewage and improper cultivation methods. The static water level changes from 6.4 to 26 m below ground level due to over exploitation of ground water.

IV. CONCLUSIONS

The hydrogeological investigations and the historical quality data of groundwater confirmed its pollution in the villages of Doppalapudi and Mannava through the over exploitation of groundwater and excess use of pesticides in agricultural fields. The following measures can be taken up to prevent deterioration of it in this area. Tidal regulators and check dams are to be constructed on the canal at suitable places with the consultation of Drainage Engineers. Exploitation of groundwater should be controlled and regulated. Recharge ponds should be constructed in the contaminated area to improving groundwater quality. Surface water from canal can be used for recharging purpose. State groundwater department will monitor the quality of groundwater by establishing observation wells in the area.

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