

Quality Evaluation of Drinking Waters of Rural Water Supplies (RWS) in West Godavari region of Andhra Pradesh

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Abstract

Water is one of the most essential components for the survival of life on the earth. According to the World Health Organization (WHO) more than 80% diseases of mankind are water borne. The present research work is focused on characterization of water samples collected before and after treatment from Rural Water Supply (RWS) schemes located at Revenue Mandal Head Quarters Ganapavaram and Nallajerla of West Godavari district during pre and post monsoon seasons for physicochemical parameters Viz., pH, Electrical conductivity (EC), Total Dissolved solids (TDS), Total hardness (TH), Total Alkalinity (TA), Na, K, Calcium and Magnesium, Chloride, Sulphate, Nitrate, Fluoride, Phosphate and Metal ions Viz., Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Ag, Cd, Cs, Ba, Tl, Pb and U to evaluate the quality of drinking waters. The study results indicated that the waters are with slightly alkaline nature. TH and TA values of post monsoon samples exceeded the permissible limit while other parametric levels of TDS, Na⁺, K⁺, Cl⁻, F⁻, NO₃⁻, SO₄²⁻, PO₄³⁻ values are within the permissible limits. The concentration of metal ions is also within the permissible limits. Higher values of hardness and total alkalinity can cause encrustation and possess unpleasant smell to waters and make the waters unsuitable for drinking domestic and purposes.

Keywords: Characterization, Drinking water, Metal, Parameter, Rural area

I. INTRODUCTION

Water is a universal solvent and acts significantly as an elixir of life. India has only 4 per cent of the global waters to meet the needs of its 1.25 billion human populations (UNEP, 2007). Drinking water quality is a powerful determinant of environmental health. Unsafe water, sanitation and hygiene kill about 2 million people annually mainly due to diarrheal diseases and children are the main victims (UNICEF, 2008). Unsanitary water is responsible for 80 per cent of all illness and is world's first killer (UN, 2003). Water scarcity threatens 2/3 of the world population by 2025 (UN-Water RIO+20 Report, 2012). Water pollution is a serious problem in our country as the safe drinking water sources are diminishing at an alarming rate. The major sources of pollution are the rivers and canals flowing nearby villages. Wastes generating from metro and urban areas pollute water sources and may affect the water table (Borchart, and Walton, 1971). Heavy metals are widespread pollutants of great environmental concern as they are toxic, non-degradable and can cause concern on aquatic ecology (Chopra et al., 2009; Jumbe and Nandini, 2009). The excessive ingestion of all metals which include Cd, Cr, Co, Hg, Ni, Pb and Zn has carcinogenic effects on human health (Muhammad et al., 2011).

II. MATERIALS AND METHODS

The sampling locations are identified in the Revenue Mandal Head Quarters of Ganapavaram and Nallajerla of Eluru Revenue Division in West Godavari District of A.P, India. Ganapavaram Revenue Mandal Head Quarters is located between the latitude and longitude 160.701 N and 810.461 E while Nallajerla Revenue Mandal Head Quarters I is located between 160.941 N and 810.401 E respectively. The details of sample code, type of source, treatment details and sampling location are presented in Table-1. The study area maps are presented in figures from 1(I) -1(IV).

RWS samples collected during pre and post monsoon periods are characterized for physicochemical parameters viz., pH, Electrical conductivity (EC), Total Dissolved solids (TDS), Total hardness (TH), Total Alkalinity (TA), Na, K, Calcium and Magnesium, Chloride, Sulphate, Nitrate, Fluoride, and Phosphate. pH determined by pH meter (Global-DPH 505,India-Model) and Conductivity measured by the digital conductivity meter (Global-DCM-900-Model). TDS is determined from the relation $TDS = \text{Electrical conductivity (EC)} \times 0.64$. Chloride, Total hardness, Total Alkalinity and Chloride are estimated by titrimetry.

Sulphate and Phosphate by spectrophotometer (Model-167, Systronics). Na and K by Flame photometer (Model-125, Systronics). The samples are analyzed as per the standard procedures (Ramteke and Moghe, 1998).

The treated water samples are further characterized for metal ions viz., Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Ag, Cd, Cs, Ba, Ti, Pb and U by employing Inductively Coupled Plasma Mass Spectrometry (ICP-MS) technique.

The analytical data of physicochemical parameters are presented in table-2 & 3 respectively.

The analytical data generated in ppb from the instrument (ICP-MS) has been converted to ppm for convenience and the details are presented in table-4.

III. RESULTS AND DISCUSSION

A. p^H :

p^H of waters collected before treatment from Ganapavaram during pre and post monsoon seasons is 7.5 and 7.7 respectively and p^H of waters collected after treatment during pre and post monsoon seasons ranges from 7.5 to 7.9 and 7.7 to 7.9 respectively.

p^H of RWS samples collected before treatment from Nallajerla during pre and post monsoon seasons is 7.0 and 7.8 respectively and p^H of waters collected after treatment during pre and post monsoon seasons ranges from 7.1 to 7.8 and 7.6 to 7.8 respectively. Water samples before and after treatment from both Ganapavaram and Nallajerla are within the permissible limit of drinking water standards (IS: 10500-1992).

B. Electrical Conductivity (EC):

EC of waters collected before treatment from Ganapavaram during pre and post monsoon seasons is 388 μ mhos/cm and 488 μ mhos/cm respectively. EC values of water samples ranges from 380 μ mhos/cm to 400 μ mhos/cm and 480 μ mhos/cm to 505 μ mhos/cm in samples collected after treatment during pre and post monsoon seasons respectively.

EC of water samples before treatment collected from Nallajerla during pre and post monsoon seasons is 1030 μ mhos/cm and 846 μ mhos/cm respectively where as samples collected after treatment during pre and post monsoon seasons ranges from 979 μ mhos/cm to 1050 μ mhos/cm and 828 μ mhos/cm to 896 μ mhos/cm respectively.

C. Total Dissolved Solids (TDS):

TDS of water samples collected before treatment from Ganapavaram during pre and post monsoon seasons is 248.3 mg/l and 312.3 mg/l respectively. TDS ranges from 243.2 mg/l to 256.0 mg/l and 307.2 mg/l to 323.2 mg/l respectively in samples collected after treatment during pre and post monsoon seasons and TDS is within the permissible limit of drinking water standards (IS: 10500-1992).

TDS of water samples collected before treatment from Nallajerla during pre and post monsoon seasons is 659.2 mg/l and 541.4 mg/l respectively where as TDS of waters collected after treatment during pre and post monsoon season ranges from 626.6 mg/l to 672.0 mg/l and 529.9 mg/l to 573.4 mg/l and TDS is within the permissible limit of drinking water standards (IS: 10500-1992).

D. Total Hardness (TH):

TH of water samples collected before treatment from Ganapavaram during pre and post monsoon seasons is 200 mg/l and 400 mg/l respectively. TH is 200 mg/l in each sample collected after treatment during pre monsoon season and TH ranges from 300 mg/l to 400 mg/l in samples collected after treatment during post monsoon season and TH is within the permissible limit (IS: 10500-1992).

TH of waters collected before treatment from Nallajerla during pre and post monsoon seasons is 300 mg/l and 500 mg/l respectively. TH is 300 mg/l in all treated samples of pre monsoon season and TH ranges from 400 mg/l to 500 mg/l in samples collected after treatment during post monsoon season and TH is within the permissible limit (IS: 10500-1992).

Higher TH of waters cause encrustation in the water supply system and cannot be considered for Domestic purposes.

E. Total Alkalinity (TA):

TA of water samples of Ganapavaram collected before treatment during pre and post monsoon season is 366 mg/l and 732 mg/l respectively and TA is 366 mg/l in all the samples collected after treatment during pre monsoon season and TA ranges from 610 mg/l to 732 mg/l in samples collected after treatment during post monsoon season and TH is within the permissible limit (IS: 10500-1992).

TA of Waters collected before treatment from Nallajerla during pre and post monsoon seasons is 610 mg/l and 732 mg/l respectively. TA of treated water samples during pre and post monsoon seasons ranges from 610 mg/l to 732 mg/l and 488 mg/l to 732 mg/l respectively. TA exceeded the permissible limit of drinking water standards (IS: 10500-1992).

Higher values of TA can alter the taste of the waters and hence the waters are not advisable for drinking.

F. Sodium (Na^+):

Na^+ concentration of water samples of Ganapavaram collected before treatment during pre and post monsoon season is 8.0 mg/l and 67.7 mg/l respectively and Na^+ concentration in water samples collected after treatment during pre and post monsoon season ranges from 7.6 mg/l to 8.0 mg/l and 37.9 mg/l to 66.3 mg/l respectively.

Na^+ concentration in Waters collected before treatment from Nallajerla during pre and post monsoon seasons is 4.8 mg/l and 23.7 mg/l respectively. Na^+ concentration in RWS samples collected after treatment during pre and post monsoon season ranges from 4.7 mg/l to 5.0 mg/l and 22.0 mg/l to 24.0 mg/l respectively.

G. Potassium (K^+):

K^+ concentration in samples before treatment collected from Ganapavaram during pre and post monsoon season is 1.8 mg/l and 8.5 mg/l respectively. K^+ concentration ranges from 1.6 mg/l to 1.7 mg/l and 5.0 mg/l to 9.6 mg/l respectively in samples collected after treatment during pre and post monsoon season.

K^+ concentration in water samples collected before treatment from Nallajerla during pre and post monsoon seasons is 0.7 mg/l and 4.6 mg/l respectively. K^+ concentration is 0.7 mg/l in all water samples collected after treatment during pre monsoon season and it ranges from 4.0 mg/l to 4.6 mg/l in samples collected after treatment during post monsoon season.

H. Calcium (Ca^{2+}):

Calcium concentration in water samples collected from Ganapavaram before treatment during pre and post monsoon season is 40 mg/l and 80 mg/l respectively. Calcium concentration is 40 mg/l in all water samples collected after treatment during pre monsoon season and it ranges from 80 mg/l to 120 mg/l in samples collected after treatment during post monsoon season and exceeded the permissible limit of drinking water standards (IS: 10500-1992).

Calcium concentration of water samples collected before treatment from Nallajerla during pre and post monsoon seasons is 80 mg/l and 120 mg/l respectively. Calcium concentration is 80 mg/l in all in water samples collected after treatment during pre monsoon season and it ranges from 80 mg/l to 120 mg/l in samples collected after treatment during post monsoon season and exceeded the permissible limit of drinking water standards (IS: 10500-1992).

I. Magnesium (Mg^{2+}):

Magnesium concentration in samples collected from Ganapavaram before treatment during pre and post monsoon season is 24.4 mg/l and 48.8 mg/l respectively. Magnesium concentration is 24.4 mg/l in all samples collected after treatment during pre monsoon season and it ranges from 24.4 mg/l to 48.8 mg/l in treated samples of post monsoon season.

Magnesium concentration in water samples collected before treatment from Nallajerla during pre and post monsoon seasons is 24.4 mg/l and 48.8 mg/l respectively and Magnesium concentration is 24.4 mg/l in all samples collected after treatment during pre monsoon season and it ranges from 48.8 mg/l to 73.2 mg/l in samples collected after treatment during post monsoon season. During post monsoon season Magnesium concentrations exceeded the permissible limit.

J. Chloride (Cl^-):

Chloride concentration of waters of Ganapavaram collected before treatment during pre and post monsoon season is 35.4 mg/l and 70.9 mg/l respectively. Chloride concentration is 35.4 mg/l in all water samples collected after treatment during pre monsoon season and it is 70.9 mg/l in all water samples collected after treatment during post monsoon season and all the values are within the permissible limit (IS: 10500-1992).

Chloride concentration in samples collected before treatment from Nallajerla during pre and post monsoon seasons is 177.2 mg/l and 141.8 mg/l respectively and in water samples collected after treatment during pre and post monsoon season ranges from 141.8 mg/l to 177.2 mg/l and 106.3 mg/l to 141.8 mg/l respectively and all the values are within the permissible limit (IS: 10500-1992).

K. Sulphate (SO_4^{2-}):

Sulphate concentration in samples of Ganapavaram collected before treatment during pre and post monsoon season is 20 mg/l and 32 mg/l respectively. Sulphate concentration of water samples collected after treatment during pre and post monsoon season ranges from 19 mg/l to 22 mg/l and 20 mg/l to 22 mg/l respectively and all are within the permissible limit (IS: 10500-1992).

Sulphate concentration of water samples collected before treatment from Nallajerla during pre and post monsoon seasons is 21 mg/l and 28 mg/l respectively, where as its concentration in samples collected after treatment during pre and post monsoon season ranges from 19 mg/l to 22 mg/l and 27 mg/l to 30 mg/l respectively. Sulphate concentration of water samples collected before and after treatment from both Ganapavaram and Nallajerla are within the permissible limit of drinking water standards (IS: 10500-1992).

L. Nitrate (NO_3^-):

Nitrate concentration in samples of Ganapavaram collected before treatment during pre and post monsoon season is 11 mg/l and 12 mg/l respectively. Nitrate concentration in all the samples collected after treatment during both pre and post monsoon season ranges from 10 mg/l to 12 mg/l.

Nitrate concentration of samples collected before treatment from Nallajerla during pre and post monsoon seasons is 15 mg/l and 14 mg/l respectively and Nitrate concentration in all the samples collected after treatment during both pre and post monsoon season ranges from 11 mg/l to 14 mg/l. Nitrate concentration in samples collected before and after treatment from both Ganapavaram and Nallajerla are within the permissible limit of drinking water standards (IS: 10500-1992).

M. Fluoride (F):

Fluoride concentration in samples of Ganapavaram collected before treatment during pre and post monsoon season is 0.41 mg/l and 0.45 mg/l respectively. Water samples collected after treatment during pre and post monsoon season ranges from 0.39 mg/l to 0.42 mg/l and 0.36 mg/l to 0.41 mg/l respectively.

Fluoride concentration of RWS samples collected before treatment from Nallajerla during pre and post monsoon seasons is 0.54 mg/l and 0.51 mg/l respectively and F- concentration in water samples collected after treatment during pre and post monsoon season ranges from 0.51 mg/l to 0.55 mg/l and 0.46 mg/l to 0.50 mg/l respectively. Fluoride concentration in water samples collected before and after treatment from both Ganapavaram and Nallajerla are within the permissible limit (IS: 10500-1992).

N. Phosphate (PO_4^{3-}):

Phosphate concentration of waters collected before and after treatment from both Ganapavaram and Nallajerla is observed at ND (Not Detected) level.

O. Metal ions:

The concentration of metal ions Viz., Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Rb, Sr, Ag, Cd, Cs, Ba, Tl, Pb and U in treated waters of pre and post monsoon season are found to be within the permissible limits of drinking water standards.

The Physicochemical parameters of drinking water samples Before treatment (BT) and After treatment (AT) are represented graphically in figures- 2(I)-2(V) & 3(I)-3(V) respectively.

IV. CONCLUSION

The waters of both Ganapavaram and Nallajerla revenue mandals are with slight alkaline nature. TDS of water of pre and post monsoon season of Ganapavaram mandal are within the permissible limit (IS: 10500-1992), where as TDS of waters of Nallajerla mandal are above the permissible limit[10] indicating the presence of soluble solid matter in drinking waters. The Total hardness of waters of post monsoon season in both Ganapavaram and nallajerla mandals exceeded the permissible limit (IS: 10500-1992), where as the levels in pre monsoon season in Ganapavaram are below permissible limit (IS: 10500-1992) and the level touched the threshold value in respect of waters of pre monsoon waters of Nallajerla mandal. Higher values of hardness can cause encrustation of waters and make the water unsuitable for domestic utilization. The total alkalinity levels of waters of both seasons in both mandals exceeded the permissible limit and hence waters can cause unpleasant smell and are not suitable for drinking purposes.

Calcium levels in waters of post monsoon season in Ganapavaram mandal and both seasons in Nallajerla mandal exceeded the permissible limit and hence can cause encrustation on water supply systems. Magnesium level in respect of waters of post monsoon season in two locations of Ganapavaram and in all location of Nallajerla exceeded the permissible limit and hence the waters can cause gastrointestinal problems. The concentrations of Chloride, Sulphate, Fluoride, Nitrate are below permissible limit and Phosphate is at Not Detected (ND) limit in all samples of the two mandals during both monsoon seasons. The metal ion concentrationa are within the permissible limit and hence can cause no concern on the human health. The waters to be treated repeatedly by the available suitable filtration methods so as to make the drinking water more safe for drinking and domestic purposes.

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Table-1:
Sample code and Sampling locations

Eluru Revenue Division			
Ganapavaram Revenue Mandal Head Quarters			
Sample Code	Type of Source	Status	Area of Sampling (Land Mark)
W-1	SW	BT	Near RWS storage lake
W-2	TW	AT	Near water tank
W-3	TW	AT	Near sivalayam
W-4	TW	AT	End of Sivalayam street
W-5	TW	AT	Main road
Nallajerla Revenue Mandal Head Quarters			
Sample Code	Type of Source	Status	Area of Sampling (Land Mark)
W-1	GW	BT	Near RWS water tank
W-2	TW	AT	Tap at Panchayathi
W-3	TW	AT	Panchayathi street
W-4	TW	AT	Tap at Bhimadole road
W-5	TW	AT	Near Ramalayam

*SW- Surface Water, GW-Ground water, TW- Treated (Tap) water, BT- Before Treatment, AT- After treatment
 The study area maps are presented in figures from 1(I) -1(IV)

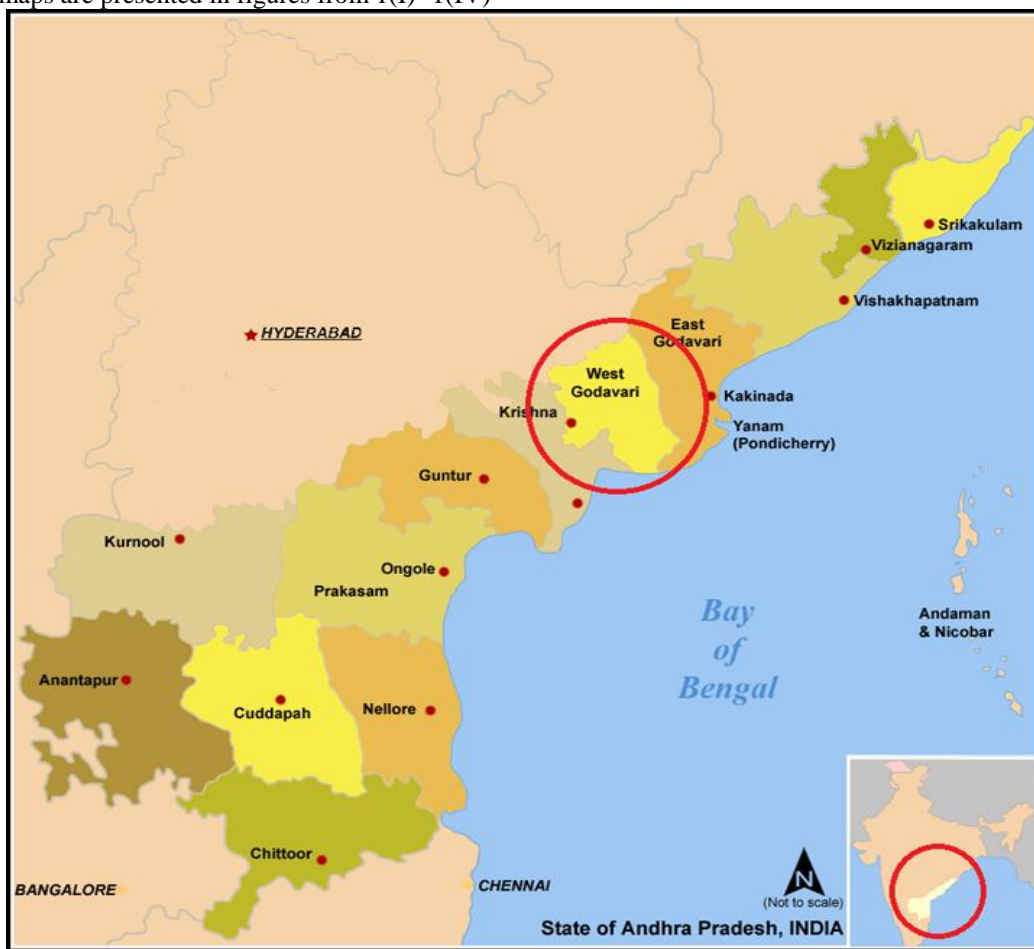


Fig. 1(I): Map of Andhra Pradesh



Fig. 1(II): Study areas in West Godavari District

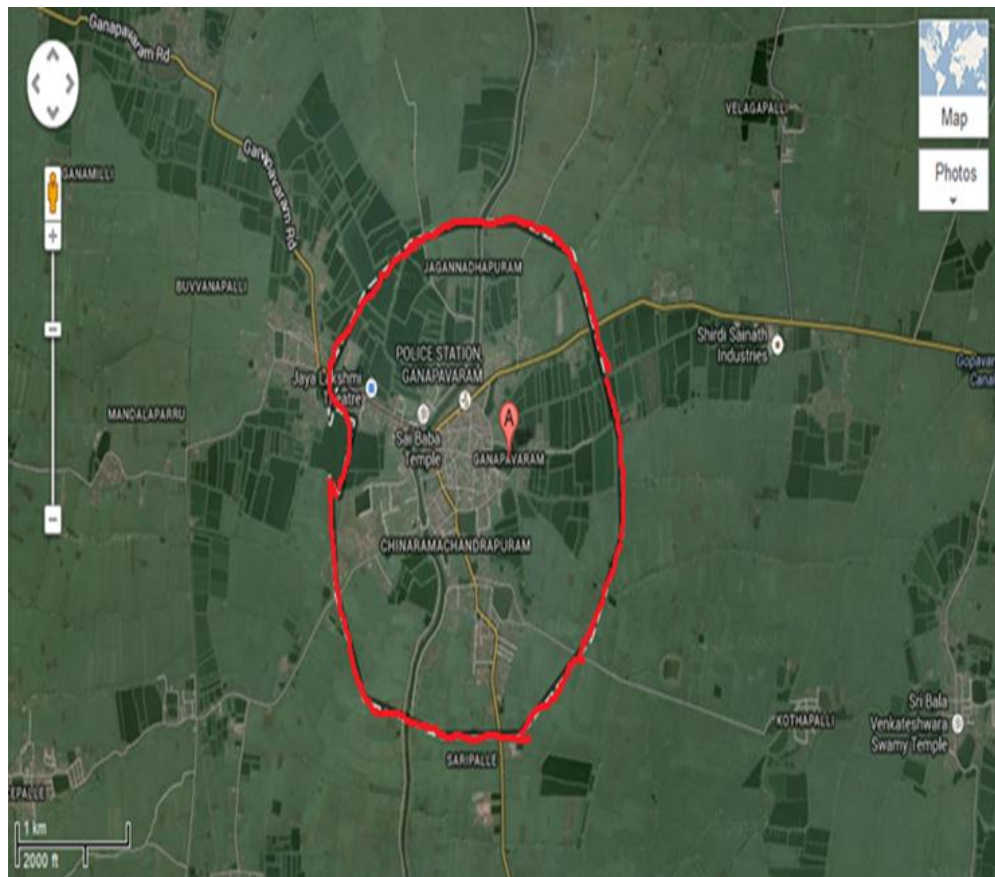


Fig. 1(III): Ganapavaram Revenue Mandal Head Quarters

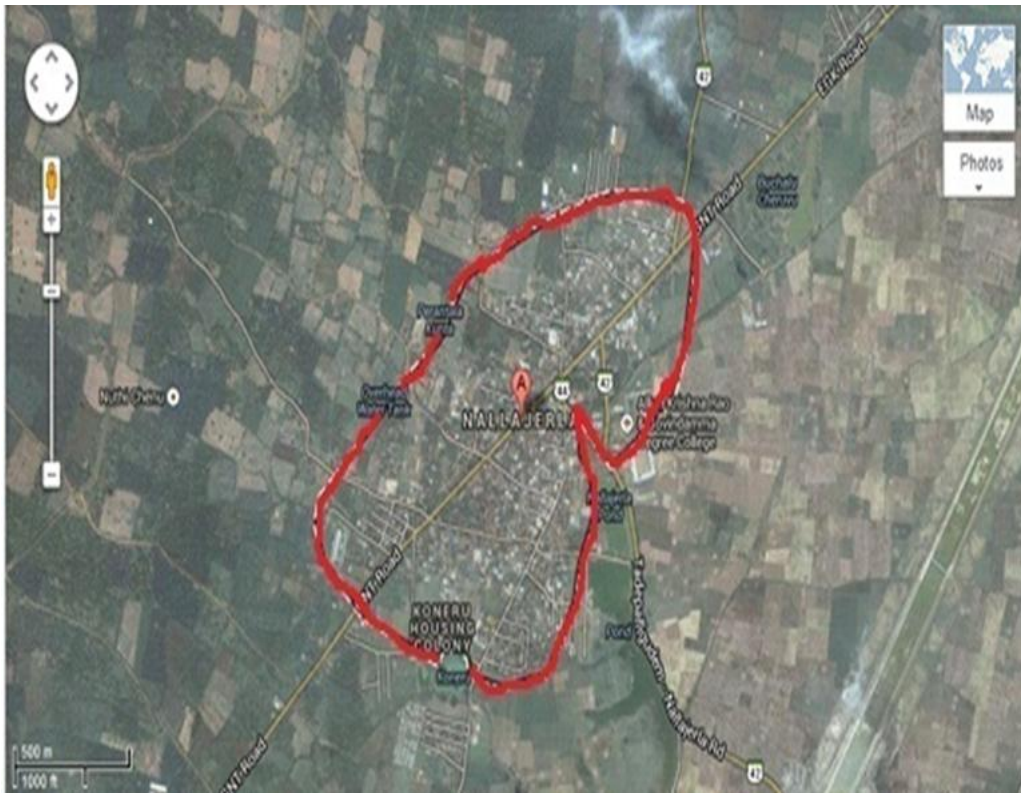


Fig. 1(IV): Nallajerla Revenue Mandal Head Quarters

Table-2
Physicochemical characteristics of drinking waters of Ganapavaram Revenue Mandal Head Quarters

Parameters	Ganapavaram Mandal Head Quarters									
	Sample Code									
	W-1		W-2		W-3		W-4		W-5	
	BT		AT		AT		AT		AT	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
p^H	7.5	7.7	7.7	7.9	7.6	7.7	7.5	7.8	7.9	7.8
EC ($\mu\text{mhos/cm}$)	388	488	380	488	400	505	400	480	398	496
TDS (mg/l)	248.3	312.3	243.2	312.3	256.0	323.2	256.0	307.2	254.7	317.4
TH (mg/l)	200	400	200	300	200	400	200	400	200	400
TA (mg/l)	366	732	366	610	366	610	366	732	366	732
Na^+ (mg/l)	8.0	67.7	7.9	66.3	8.0	64.1	7.6	63.8	7.6	37.9
K^+ (mg/l)	1.8	8.5	1.7	9.6	1.7	8.3	1.6	8.1	1.6	5.0
Ca^{2+} (mg/l)	40	80	40	80	40	120	40	120	40	80
Mg^{2+} (mg/l)	24.4	48.8	24.4	24.4	24.4	24.4	24.4	24.4	24.4	48.8
Cl ⁻ (mg/l)	35.4	70.9	35.4	70.9	35.4	70.9	35.4	70.9	35.4	70.9
SO_4^{2-} (mg/l)	20	32	19	22	20	20	20	22	22	21
NO_3^- (mg/l)	11	12	10	10	12	10	11	12	10	12
F ⁻ (mg/l)	0.41	0.45	0.39	0.36	0.40	0.38	0.42	0.41	0.41	0.39
PO_4^{3-} (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

*ND-Not Detected

Table -3:
Physicochemical characteristics of drinking waters of Nallajerla Revenue Mandal Head Quarters

Parameters	Nallajerla Mandal Head Quarters									
	Sample Code									
	W-1		W-2		W-3		W-4		W-5	
	BT		AT		AT		AT		AT	
	Monsoon		Monsoon		Monsoon		Monsoon		Monsoon	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
p ^H	7.0	7.8	7.1	7.7	7.1	7.7	7.8	7.6	7.2	7.8
EC (µmhos/cm)	1030	846	1050	849	1040	896	979	828	1030	832
TDS (mg/l)	659.2	541.4	672.0	543.3	665.6	573.4	626.6	529.9	659.2	532.4
TH (mg/l)	300	500	300	500	300	500	300	400	300	500
TA (mg/l)	610	732	732	610	732	732	610	732	610	488
Na ⁺ (mg/l)	4.8	23.7	4.7	24.0	4.9	22.9	4.8	22.0	5.0	22.1
K ⁺ (mg/l)	0.7	4.6	0.7	4.6	0.7	4.1	0.7	4.0	0.7	4.2
Ca ²⁺ (mg/l)	80	120	80	120	80	120	80	80	80	80
Mg ²⁺ (mg/l)	24.4	48.8	24.4	48.8	24.4	48.8	24.4	48.8	24.4	73.2
Cl ⁻ (mg/l)	177.2	141.8	177.2	141.8	177.2	141.8	141.8	106.3	141.8	141.8
SO ₄ ²⁻ (mg/l)	21	28	19	30	19	27	22	27	21	30
NO ₃ ⁻ (mg/l)	15	14	13	12	14	12	11	14	12	11
F ⁻ (mg/l)	0.54	0.51	0.52	0.50	0.53	0.49	0.55	0.48	0.51	0.46
PO ₄ ³⁻ (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table-4
Metal ion concentration in treated RWS waters

Metal ion Concentration (ppm)	Sample location (Revenue Mandal Head Quarters)			
	Ganapavaram		Nallajerla	
	Monsoon		Monsoon	
	Pre	Post	Pre	Post
Li	0.001358	0.001554	0.005758	0.005328
Be	ND	ND	ND	ND
Al	0.002499	0.008076	0.016822	0.010825
V	0.008597	0.005877	0.001259	0.001791
Cr	0.000203	0.000680	0.000970	0.000954
Mn	0.000144	0.000432	0.002396	0.000379
Fe	0.002903	0.009452	0.017299	0.004895
Co	0.000014	0.000047	0.000026	0.000041
Ni	0.000439	0.001765	0.001176	0.000739
Cu	0.001100	0.004065	0.002439	0.000704
Zn	0.002077	0.028415	0.011911	0.003752
As	0.001069	0.000820	0.000100	0.000153
Rb	0.002928	0.002182	0.016301	0.014706
Sr	0.158141	0.200517	0.489604	0.688165
Ag	0.000013	0.000043	0.000066	0.000068
Cd	0.000013	0.000055	0.000042	0.000013
Cs	ND	ND	0.000201	0.000179
Ba	0.050181	0.063469	0.019861	0.024195
Tl	ND	ND	ND	0.000001
Pb	0.000135	0.001061	0.002050	0.000315
U	0.000360	0.000725	0.003057	0.005054

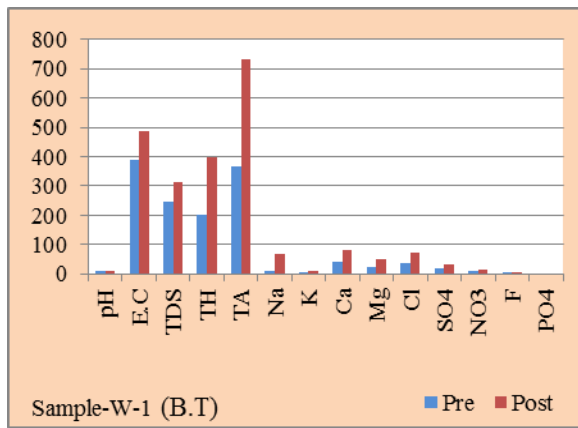


Fig. 2(I)

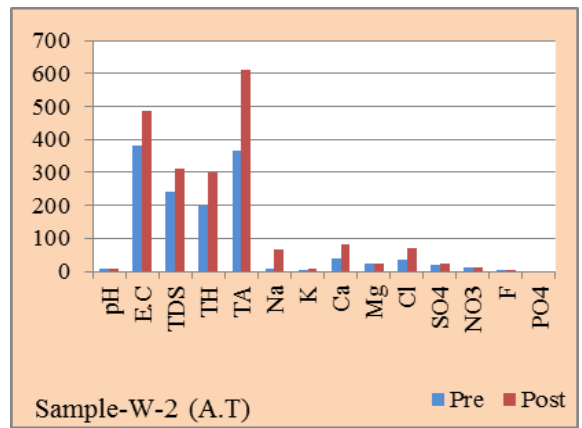


Fig. 2(II)

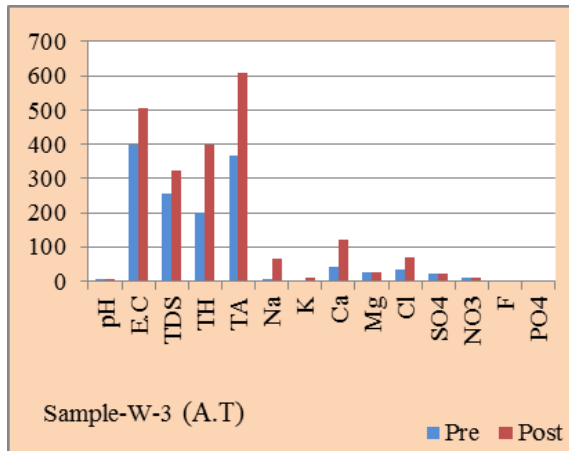


Fig. 2(III)

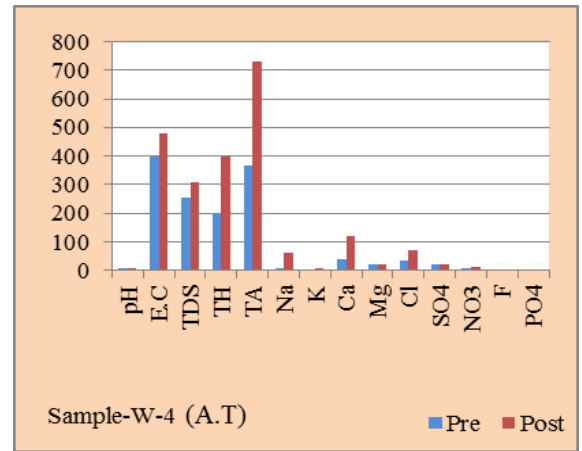


Fig. 2(IV)

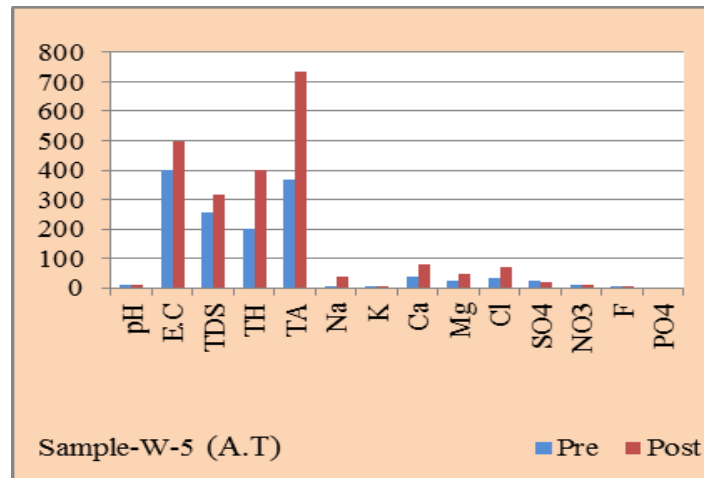


Fig. 2(V)

Fig. 2(I) - 2(V): Characteristics of RWS drinking waters (BT& AT) of Ganapavaram Revenue Mandal Head Quarters during pre and post monsoon seasons

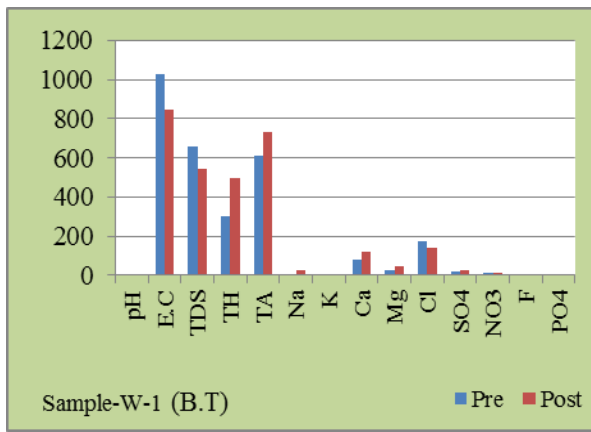


Fig. 3(I)

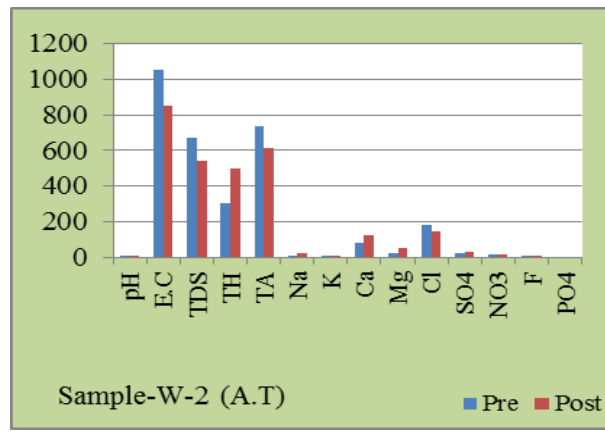


Fig. 3(II)

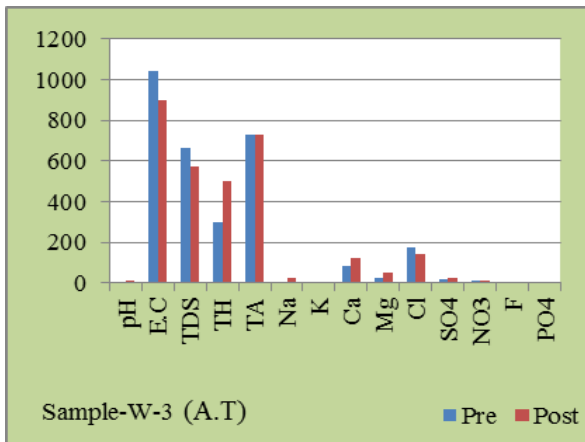


Fig. 3(III)

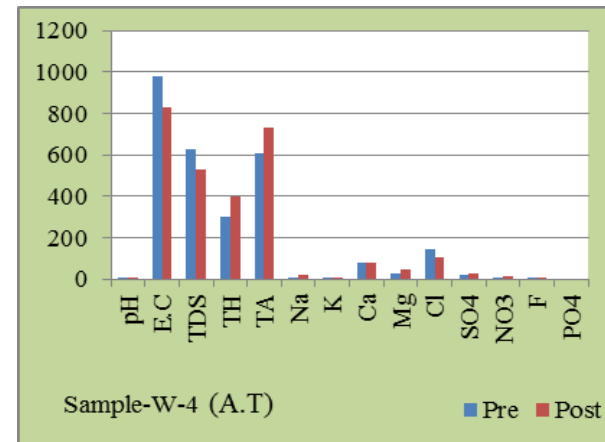


Fig. 3(IV)

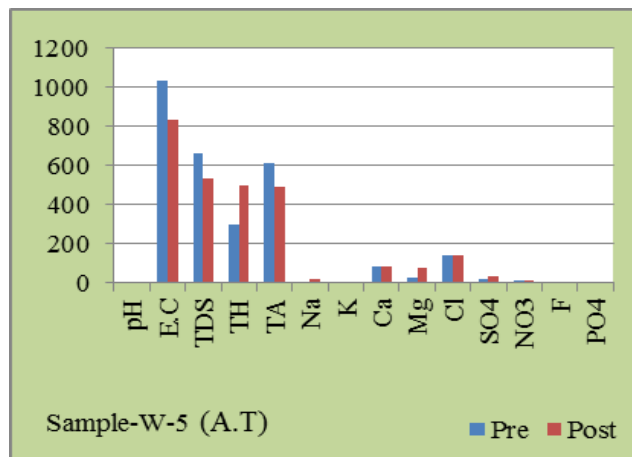


Fig. 3(V)

Fig. 3(I)- 3(V): Characteristics of RWS drinking waters (BT& AT) of Nallajerla Revenue Mandal Head Quarters during pre and post monsoon seasons