

Physico-Chemical and Biological Analysis of Drinking Water status in Narsapur Canal area with Seasonal Variation in West Godavari District, Andhra Pradesh, India- A Case Study

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ABSTRACT

Drinking water is a basic requirement for life and a determinant of standard of living. However, besides government efforts, supply and demand side factors of both surface and ground water determine the level of drinking water available to the people. A physico-chemical and micro biological study in thirty villages of Narsapur canal area has been carried out to assess the quality of drinking water sources. Water samples have been collected from sources like canal, ground water (Before treatment) and public and municipal treated water (after treatment) of both the sources of waters. The samples have been collected for two seasons and analyzed for Turbidity, pH, TDS, EC, Hardness, Alkalinity, DO, BOD, COD, Ammonia, Nitrites, Nitrates, Sodium, Potassium, Chlorides, MPN, TFC, *E.Coli* etc. Seasonal variations of all these parameters are also presented. The resulted parameters are compared with the drinking water standards of WHO and BIS: 10500. Poor water quality problem has been observed in more number of villages. Inadequate resource management and institutional systems seems to be major causes for present problems.

KEY WORDS: Drinking water, physico-chemical, before treatment, after treatment, resource management.

1. INTRODUCTION

Drinking water is from different sources. Surface water can be found over the land surface in streams, ponds, lakes or other fresh water sources. Groundwater is located beneath the surface in soil pore spaces and in permeable geological formations. Sources of groundwater include seepage from the land surface; such as rain water, snow melt and water also that penetrates down from the bottom of some lakes and rivers. Fossil groundwater is water that has been trapped rock formations over geological time scales. The average availability of water remains more or less fixed according to the natural hydrological cycle but the per capita availability reduces steadily due to an increase in population. Some 2.78 million trillion gallons of ground water, 30.1 percent of the world fresh water, are estimated for the entire planet of the Earth (Banerjee, 1967).

Each source of water has a unique set of contaminants. Surface water pollution is the pollution of aquatic systems that are above ground, such as streams, lakes and rivers. These waters become polluted when rain water runoff carries pollutants into the water. The pollutants transported by runoff are from things like salts and chemicals from city and highway roads and nutrients and fertilizers from farmlands. When pollution is caused by nutrients and fertilizers that is called nutrient pollution. Surface water may also be polluted with pathogens and waterborne diseases causing germs, which are usually the result of sewage leaks and runoff from animal factories. These viruses and bacteria that pollute the water may cause dangerous human health problems such as Giardia, Typhoid and Hepatitis. Toxic chemicals may also lead to surface water pollution. These come from pesticides, synthetic chemicals such as petroleum products, mercury, lead and arsenic from mining drainages. These chemicals are very dangerous for the environment as well as for the health of the organisms that inhabit them. The presence of ammonia in surface waters can be due to direct contamination by agricultural fertilizers, and/ or to microbial degradation of proteins, nucleic acids and urea, implying therefore the presence of a considerable concentration of organic matter in the water. As groundwater flows through sediments, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water. 3,4Industrial discharges, urban activities, pesticides and fertilizers used in agriculture and disposal of wastes all can affect groundwater quality. Municipal sources of groundwater contamination include open dumpsites, poorly constructed or maintained landfills, latrines and other waste sites. Each of these can contain a range of pathogens and toxins, including heavy metals that can migrate downwards and contaminate aquifer.

Groundwater pollution differs from surface water in several important respects. Among them, it does not typically flow to a single outlet. It can affect people through wells dug in a contaminated aquifer, as it can flow into streams and lakes. Groundwater pollution also occurs on a different timescale than surface water contamination. Flow rates vary widely and can be as slow as 2 miles a year. This is because groundwater experiences far more friction as it moves through the pores in soil than surface water. Surface water is more easily contaminated than groundwater. Filtration through the soil helps to clean the ground water. These distinctions depend on topography, hydrology and the source of ground water recharge and have implications for limiting as well as remediating contamination (Devaraju, 2005; Garg, 2006).

The hydrological cycle interconnects surface and groundwater which means they may contaminate one another. As rain falls on the earth's surface, some water runs off the land to rivers, lakes, streams and oceans. Some water is also evaporated and absorbed by plants or continues to move down to become groundwater. Groundwater very slowly moves towards low areas such as streams and lakes which are once again end up in surface water. This cycle is continuous and shows how the two are interconnected.

Neither water source can ever be entirely free from water contaminants. Health effects of groundwater pollution depend on the specific pollutant in the water. Pollution from groundwater often causes diarrhea and stomach irritation. Accumulation of heavy metals and some organic pollutants can lead to cancer, reproductive abnormalities and other more severe health effects. Nitrates in drinking water can cause cyanosis, a reduction of the oxygen carrying capacity of the blood. Lead is a toxic substance and is very dangerous particularly for children. Other heavy metals present in groundwater are cadmium, zinc, mercury etc. (Hujare 2008; Jayaraman, 2003; Kadam, 2007).

Study Area: West Godavari is one of the 13 districts of Andhra Pradesh, India. West Godavari district occupies an area approximately 7700 square kilometers; it has 46 mandals; out of which 20 are in upland and the rest in deltaic region. The delta region is abundant with water sources and so agriculture, aquaculture and industries based on these agri and aqua are thriving well. The samples are collected from Narsapur canal and the villages along this canal. The collection of the samples includes canal water of selected points and ground water samples where the public is based on this source for drinking water. Ground water includes well water, bore water and hand pumps. Water samples are also collected after treatment by Rural Water Supply plants and Municipal Water Treatment plants. Total 30 villages are selected in this area for the collection of the samples. Out of 30, thirteen villages are based on canal water with summer storage tanks and treatment plants. Another fifteen villages are based on ground water with or without any storage tanks and with or without any treatment plants. Two municipalities also based on canal water (Narsapur and Palakollu) have well established municipal treatment plants with huge summer storage tanks, treatment plants with sedimentation, coagulation by alum, filtration by rapid sand filtration method and chlorination by liquefied chlorine gas.

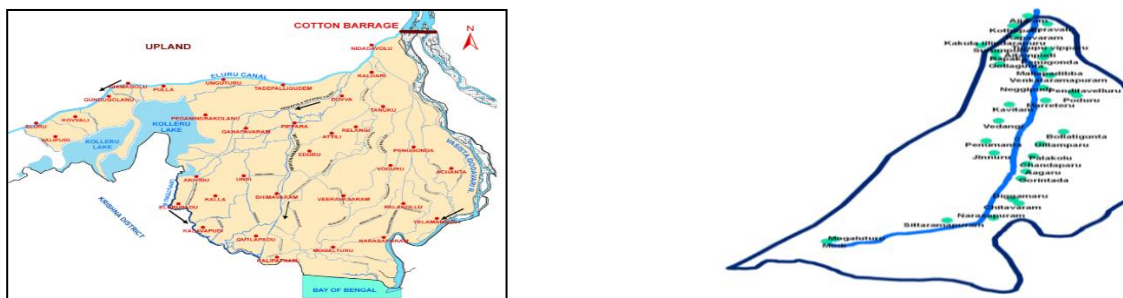


Figure.1. Study area map

Drinking water samples of both surface and groundwater are collected from all the surface and Ground water in Narsapur canal area. The samples are collected from 30 villages namely- Peravali, Kothapalli, Kapavaram, Toorpu, Vipparru, Kakula Illindaparru, Surampudi, Rapaka, Gollagunta, Aitampudi, Penugonda, Mallapudibba, Venktaramapuram, Marteru, Pandithavalluru, Kavitam, Poduru, Vedangi, Bolligunta, Penumantra, Jinnuru, Ullamparru, Palakollu, Chandaparru, Aagarru, Digamarru, Chittavaram, Narasapuram, Sitaramapuram, Mogalturu and Modi. These samples are analyzed for various physico- chemical and biological parameters like pH, TDS, Calcium hardness, Magnesium hardness, Total hardness, Carbonate alkalinity, Bicarbonate alkalinity, Total alkalinity, Ammonia, Nitrite, Nitrate, Sodium, Potassium, Chloride, Dissolved Oxygen, BOD, COD, MPN, TFC, E.Coli etc. These water samples are analyzed according to standard protocol (Chisty, 2002). These samples were collected in two phases during November, December months of 2014 and January, February months of 2015 (First Season) and August to November months of 2015 (Second Season) and analyzed as per standard protocol (Khan and Choudhary, 1994).

2. RESULTS AND DISCUSSION

Physical properties: The density of the Hemp, Jute and Glass Fibre was found to be 1.48, 1.46 and 2.55 g/cm³ (Wambua, 2003), respectively.

Tensile Properties: The variation of mean tensile strength with differing volume of fibre is given in Figure.2. It was observed that by increasing the volume of fibre in the composite, the tensile strength also increases. The percentage increase in tensile strength of the composites at the maximum fibre content (40 volume percentage of fibre) is discovered to be 21.40 MPa. The increase in tensile strength is due to the resin transmitting as well as distributing the applied stress to the Hemp, Jute and Glass fibre.

Table.1. Physico-chemical parameters of canal water-Phase I

Village	pH	TDS (ppm)	EC ($\mu\text{s}/\text{cm}$)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Ajjaram	8.40	130	190	80	75	0.40	0.01	0.01	4.10	27	1	21.50
Peravali	8.49	130	190	70	70	0.10	0.02	0.01	6.05	25	1	24.25
Kapavaram	8.48	130	180	100	90	0.80	0.07	0.01	6.00	31	2	20.25
Toorpu Vipparru	8.54	135	200	90	90	0.20	0.01	0.00	5.04	41	5	28.75
Rapaka	8.64	125	180	80	80	0.20	0.04	0.01	6.70	30	1	32.54
Gollagunta	8.52	130	190	90	85	0.20	0.06	0.02	7.01	32	2	38.36
Aitampudi	8.60	130	180	90	80	0.40	0.01	0.02	6.90	29	1	44.54
Penugonda	8.70	130	180	90	85	0.70	0.02	0.00	7.40	30	2	52.80
Neggipudi	8.60	135	180	100	90	0.60	0.02	0.07	6.00	31	2	56.35
Marteru	8.52	130	180	90	80	0.20	0.02	0.00	9.00	32	2	63.34
Poduru	8.16	140	190	80	80	0.10	0.02	2.40	10.0	33	2	65.25
Vedangi	8.54	140	200	80	75	0.10	0.10	0.01	10.2	29	5	70.10
Penumantra	8.54	140	200	75	80	1.20	0.12	0.01	10.8	30	2	56.76
Jinnuru	8.53	140	200	80	85	0.80	0.05	0.05	20.7	30	2	42.57
Uilamparru	8.49	140	200	90	80	0.70	0.01	0.02	24.7	30	3	42.57
Palakollu	8.54	140	210	80	80	1.10	0.00	0.01	26.5	30	2	42.57
Chandaparru	8.49	150	220	85	105	2.10	0.01	0.00	19.3	32	2	56.76
Agarru	8.15	160	240	85	90	0.6	0.02	0.64	16.0	35	2	42.57
Gorintada	8.33	140	210	85	95	1.0	0.01	0.03	20.8	30	2	42.57
Digamarru	8.54	140	210	110	95	1.6	0.01	0.02	28.1	30	2	42.57
Chittavaram	8.19	140	210	95	95	2.2	0.02	0.02	21.6	31	3	42.57
Narsapuram	8.14	150	220	90	110	0.6	0.02	0.00	14.8	36	2	42.57
Sitarampuram	8.21	140	210	75	90	1.5	0.02	0.03	16.4	29	2	42.57
Mogalturu	8.29	140	210	75	95	1.2	0.02	0.04	12.8	30	2	28.38
Averages	8.40	137	199	85	86	0.73	0.03	0.14	13.2	31	2	35.77

In first season more or less all the parameters of canal water are within the standard limits except PH which has higher values at some points like Toorpu Vipparru, Rapaka, Gollagunta, Aitampudi, Penugonda, Neggipudi, Marteru, Vedangi, Penumantra, Jinnuru, Palakollu and Digamarru. The minimum pH value 8.14 has been recorded at Narsapuram and maximum 8.70 at Penugonda with an average of 8.40. The TDS minimum value is 125ppm at Rapaka and maximum 160ppm at Agarru with an average value of 137ppm, correspondingly the minimum EC value at Rapaka is 180 $\mu\text{s}/\text{cm}$ and maximum at Agarru with 240 $\mu\text{s}/\text{cm}$ and average is 199 $\mu\text{s}/\text{cm}$. The total hardness value 70ppm is minimum at Peravali and maximum 110ppm at Digamarru with an average of 85ppm. The alkalinity is minimum 70ppm at Peravali and maximum 110ppm at Narsapuram with an average of 86ppm. Turbidity minimum value is 0.10NTU at Peravali and maximum 2.10 NTU at Chandaparru with an average of 0.73NTU. Ammonia and nitrite values are negligible and nitrates are minimum 4.1ppm at Ajjaram and maximum 28.1ppm at Digamarru with an average of 13.2ppm. Sodium value is minimum with 25ppm at Peravali and maximum with 41ppm at Toorpu Vipparru with an average of 31ppm. Potassium values are negligible, whereas chloride value is minimum 20.25ppm at Kapavaram and maximum 70.10ppm at Vedangi with an average of 35.77ppm.

Table.2. Narsapur Canal Water- Second Season

Village	pH	TDS (ppm)	EC ($\mu\text{s}/\text{cm}$)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Ajjaram	7.90	140	200	90	70	5.8	0.01	0.00	2.65	32	15	14.18
Peravali	8.56	140	200	90	70	6.0	0.01	0.00	1.87	28	9	92.17
Kotthapalli	8.56	140	200	130	80	6.2	0.00	0.00	2.45	4	6	106.35
Kapavaram	8.63	160	220	120	50	5.8	0.01	0.00	2.02	41	11	120.53
Thorpu Vipparru	8.93	140	200	90	80	5.9	0.00	0.00	2.47	3	5	85.08
Kakula-illindaparru	9.09	160	220	140	80	5.7	0.00	0.00	3.23	4	7	92.15
Surampudi	8.55	140	200	130	50	5.9	0.01	0.09	2.27	17	13	113.44
Rapaka	8.68	150	210	80	80	5.7	0.00	0.00	5.43	60	20	21.27
Gollagunta	8.40	130	180	90	80	5.3	0.00	0.00	1.92	5	17	141.80
Aitampudi	8.90	150	210	110	80	5.0	0.00	0.00	1.88	2	12	113.44
Penugonda	8.76	150	210	80	80	4.8	0.00	0.00	3.01	12	14	141.8
Mallapudibba	8.40	140	200	80	80	5.0	0.00	0.00	3.30	5	17	99.26
Venkataramapuram	8.45	190	270	90	80	4.5	0.00	0.01	2.55	21	14	29.00
Neggipudi	8.40	150	210	70	90	4.4	0.01	0.00	4.09	14	22	120.53
Marteru	8.34	160	230	80	100	4.5	0.01	0.00	4.04	5	17	92.17
Kavitam	8.05	140	200	90	60	4.3	0.01	0.00	2.30	23	20	148.0
Poduru	8.93	180	260	110	70	4.1	0.01	0.12	3.51	38	17	113.44
Vedangi	8.54	140	200	110	90	4.3	0.00	0.00	2.09	25	24	163.07
Jinnuru	8.25	190	270	90	60	4.1	0.00	0.00	2.35	20	11	148.89
Penumantra	8.72	230	330	100	40	4.0	0.01	0.01	4.04	27	3	170.16
Uilamparru	8.20	210	310	130	70	4.1	0.00	0.00	3.94	23	1	184.30

Palakollu	8.30	170	250	110	70	4.4	0.00	0.00	2.98	27	1	99.26
Chandaparru	8.50	160	240	90	70	4.9	0.00	0.00	3.30	22	1	92.17
Agarru	8.30	210	310	70	60	4.3	0.00	0.00	3.61	22	1	113.44
Gorintada	8.30	170	250	90	70	4.3	0.00	0.00	2.90	25	2	141.80
Digamarru	8.30	180	270	160	70	4.5	0.01	0.00	3.21	26	2	121.53
Chittavaram	8.30	190	280	150	60	4.2	0.01	0.00	3.21	24	1	120.53
Narsapuram	8.25	160	230	130	60	4.0	0.00	0.00	2.85	16	1	113.44
Sitaramapuram	8.60	170	240	90	90	4.2	0.00	0.00	3.61	19	1	141.80
Mogalturu	8.70	370	530	150	90	3.9	0.01	0.01	6.17	72	5	141.80
Average	8.49	170	244	104	72	4.8	0.004	0.008	3.10	22	9.6	113.00

In the second season pH values are higher at Peravali, Kottapalli, Kapavaram, Toorpu Vipparru, kakulaillindaparru, Surampudi, Rapaka, Poduru, Vedangi, Sitaramapuram and Mogalturu. pH value is minimum 7.90 at Ajaram and Maximum 9.09 at Kakula illindaparru with an average of 8.49. TDS minimum value is 130ppm at Gollagunta and maximum 370 ppm at Mogalturu with an average of 170ppm. Similarly EC minimum value is 180 μ s/cm at Gollagunta and maximum 530 μ s/cm at Mogalturu with an average of 244 μ s/cm. Total hardness minimum value is 70ppm at Neggipudi and maximum 160ppm at Digamarru with an average of 104ppm. Alkalinity values varies from 40 ppm at Penumantra to 100ppm at Marteru with an average of 72ppm. Turbidity values are ranged from 3.9NTU at Mogalturu to 6.2NTU at Kothapalli with an average of 4.8NTU. Ammonia and Nitrite values are negligible whereas nitrate values are ranged from 1.87ppm at Peravali to 6.17ppm at Mogalturu with an average of 3.10NTU. Sodium values are ranged from 2.00ppm at Aitampudi to 72ppm at Mogalturu with an average of 22ppm. Potassium value is ranged from 1.0ppm to 24.00 ppm with an average of 9.6ppm. The value of Chlorides is minimum 14ppm at Ajaram and maximum 170.16ppm at Penumantra with an average of 113.00ppm.

Table.3. Comparison of average values physico-chemical parameters of canal waters in two seasons

Phase	PH	TDS	EC	TH	TA	Turb	NO ₃	Na	K	Cl
1 st Phase	8.40	137	199	85	86	0.7	13.2	31	2.0	35
3 rd Phase	8.49	170	244	104	72	4.8	3.10	22	9.6	113

As shown in the table the average value of PH is increased from 8.40 to 8.49; TDS from 137ppm to 170ppm; EC values from 199 μ s/cm to 244 μ s/cm, Hardness values from 85ppm to 104ppm, turbidity from 0.7NTU to 4.8NTU, Potassium values from 2.0ppm to 9.6ppm and chloride values from 35ppm to 113ppm. The alkalinity average value is decreased from 86ppm to 72ppm, nitrates 13.2ppm to 3.10ppm, and sodium 31ppm to 22ppm. Irrespective of the changes in the parameters all are within the permissible limits.

Table.4. Narsapur canal Area Ground Water Analysis-1st Phase

Village	PH	TDS (ppm)	EC (μ s/cm)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)
Ajaram	8.55	640	920	310	300	0.9	0.01	0.06	32.7
Peravali	8.22	810	1160	170	150	1.0	0.00	0.02	41.8
Kottapalli	7.51	780	1120	340	425	0.2	0.00	0.01	56.9
Kapavaram	8.24	910	1300	270	370	0.8	0.00	0.40	27.4
Thurpುವಿಪ್ಪಾರ್ರು	7.93	640	920	310	225	0.9	0.00	0.08	25.7
Kakula Illindaparru	8.33	870	1250	120	525	1.2	0.00	0.00	12.8
Gollugunta	8.00	390	560	210	390	0.1	0.00	0.00	44.3
Neggipudi	8.17	940	1350	410	440	0.7	0.05	0.53	13.9
Marteru	8.05	660	950	230	320	0.9	0.20	0.53	18.9
Kavitam	8.17	880	1260	200	410	1.1	0.00	0.01	27.0
Jinnuru	8.42	410	590	145	210	1.4	0.02	0.05	1.40
Average	8.14	712	1034	247	342	0.83	0.02	0.12	27.5

Village	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)	DO (ppm)	BOD (ppm)	COD (ppm)
Ajaram	32.7	95	7	88.0	7.1	5.4	9.6
Peravali	41.8	157	14	145.6	6.5	3.6	12.8
Kottapalli	56.9	28	6	175.0	6.4	3.6	12.8
Kapavaram	27.4	92	24	128.0	5.6	6.0	16.4
Thurpುವಿಪ್ಪಾರ್ರು	25.7	100	27	54.80	6.8	4.6	12.6
Kakula Illindaparru	12.8	174	2	55.05	6.5	2.5	12.8
Gollugunta	44.3	86	4	25.35	4.7	2.4	16.0
Neggipudi	13.9	135	6	145.5	4.1	11.2	21.5
Marteru	18.9	140	20	63.5	6.3	4.8	22.4
Kavitam	27.0	162	2	91.7	4.2	12.6	25.6
Jinnuru	1.40	86	21	99.3	5.4	8.8	22.4
Average	27.5	114	12	97.40	5.70	5.9	16.8

In first phase almost all the samples of ground water have PH values within the limits except at Ajaram where the value is slightly higher than the stipulated limit. The PH values of ground water have lower values than canal water. The minimum PH value of ground water in this area is 7.51 at Kothapalli and maximum 8.55 at Ajaram with an average of 8.14. The TDS and EC values are very high in comparison to canal water and crossed the permitted limit at Ajaram, Peravali, Kothapalli, Kapavaram, Toorpu Vipparru, kakulaillindaparru, Neggipudi, Marteru and Kavitam. The minimum value of TDS is 390ppm at Gollagunta and maximum 940ppm at Neggipudi with an average of 712ppm. Similarly EC 560 μ s/cm at Gollagunta and 1350 μ s/cm at Neggipudi with an average of 1034 μ s/cm. Total hardness values are very high when compared to canal water and crossed the permissible limits at all the villages except Peravali, Kapavaram, Kakulaillindaparru, Gollagunta, Marteru, kavitam and Jinnuru. The minimum hardness value is at kakula illindaparru with 120ppm and maximum 410ppm at Neggipudi with an average of 247ppm. The Total alkalinity is very high and crossed the permissible limit in all the points except Peravali. The minimum value is 150ppm at Peravali and maximum 525ppm at Kakula illindaparru with an average of 342ppm. Turbidity values are very low in comparison to canal water. Ammonia, nitrite values are in traces whereas nitrates are more in some points and crossed the permissible limits, particularly at kothapalli it has crossed the permissible limit. In other points even though the value is not crossed the permissible limit the Nitrates are high in Peravali and Gollagunta ground waters. The minimum value of nitrate is 1.40ppm at Jinnuru and maximum 56.9ppm at Kothapalli with an average of 27.5ppm. Sodium and potassium values are high when compared to canal water and sodium values crossed 150ppm at Peravali, Kakula illindaparru and kavitam. The minimum value of sodium is 28ppm at Kothapalli and maximum 174 at Kakula Illindaparru. The potassium values are minimum 2ppm at kavitam and maximum 27 ppm at Toorpuvipparru with an average of 12ppm. Chlorides are minimum at Gollagunta with the value 25.35ppm and maximum at Kothapalli with 175ppm with an average of 97.40ppm. DO values are less than 5ppm at three points, viz. Neggipudi, Kavitam and Jinnuru. The value is Minimum 4.1ppm at Neggipudi and maximum 7.1ppm at Ajaram with an average of 5.9ppm. Similarly BOD values crossed the permissible limits at Neggipudi, Kavitam and Jinnuru with minimum 2.4 at Gollagunta and maximum 25.6ppm at Kavitam village with an average of 5.9ppm. C.O.D Values have crossed the permissible limits in all the villages except Ajaram. The values have varied from 9.7ppm at Ajaram to 25.6ppm at kavitam with an average of 16.8ppm. So, in general ground water is also contaminated and not fit for drinking purpose. The aquifers are shallow in nature and there by pollutants from agriculture, aquaculture and other sources like industrial and domestic waste are also entered and cause contamination.

Table.5. Narsapur canal Area Ground water Analysis-2nd Phase

Village	PH	TDS (ppm)	EC (μ s/cm)	TH (ppm)	TA (ppm)	Turb (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Ajaram	7.80	740	1050	460	270	5.0	0.01	0.00	12.24	134	18	184.34
Peravali	8.00	870	1240	210	260	5.2	0.00	0.00	4.12	520	20	262.33
Kothapalli	8.51	850	1210	330	340	4.1	0.23	2.85	2.46	310	30	155.98
Kapavaram	8.25	950	1360	320	140	5.1	0.11	0.12	35.09	90	30	241.06
Thorpu Vipparru	8.73	700	1000	400	200	5.0	0.01	0.00	30.20	181	16	205.61
Kakula-illindaparru	8.50	720	1030	70	50	4.6	0.00	0.29	9.56	190	17	106.35
Gollagunta	8.54	460	660	160	220	5.1	0.00	0.00	1.10	230	160	99.26
Neggipudi	8.45	990	1410	360	310	3.1	0.01	0.00	5.41	460	240	262.33
Marteru	8.48	960	1370	270	310	4.0	0.01	0.00	1.06	670	190	269.42
Kavitam	8.30	800	1140	190	200	4.0	0.01	0.01	2.78	330	230	205.61
Jinnuru	8.15	1190	1700	350	250	2.8	0.00	0.00	2.98	141	20	389.95
Averages	8.33	839	1197	283	231	4.3	0.03	0.29	9.72	296	88	216.56

pH values have increased slightly when compared to 1st Phase. At Kottapalli, Thoerpu Vipparru and Gollagunta it has crossed the permissible limits. The PH value is minimum at Ajaram and maximum at Toorpu Vipparru with an average of 8.33. TDS and EC values have crossed the permissible limits in all the points except at Gollagunta. The value is minimum 460ppm at Gollagunta and maximum 1190ppm at Jinnuru with an average of 839ppm. Similarly EC value is minimum 660 μ s/cm at Gollagunta and maximum 1700 μ s/cm at Jinnuru with an average of 1197 μ s/cm. Total Hardness has crossed the permissible limit at Ajaram, Kottapalli, Kapavaram, Toorpu Vipparru, Neggipudi and Jinnuru. The value is minimum 70ppm at Kakula illindaparru and maximum 460ppm at Ajaram with an average of 283ppm. Total alkalinity also crossed the permissible limit at Ajaram, Peravali, Kottapalli, Gollagunta, Neggipudi, Marteru and Jinnuru. The values are minimum 50 ppm at Kakula illindaparru and maximum 340 ppm at Kottapalli with an average of 231ppm. Turbidity values crossed the permissible limits at Peravali, kapavaram and Gollagunta. The minimum value 2.8NTU is at Jinnuru and maximum 5.2NTU at Peravali with an average of 4.3NTU. Ammonia is almost nil at all the points except Kottapalli and kapavaram with 0.23 and 0.11ppm respectively. Similarly the nitrite values are negligible except at Kottapalli with 2.85 ppm. The nitrate values are high but not crossed the permissible limits at any place. The minimum value is 1.06ppm at Marteru and maximum 35.09ppm at Kapavaram with an average of 9.72ppm. Sodium values are high at Peravali, Marteru,

Gollagunta, Neggipudi and kavitam. The value 90ppm is minimum at Kapavaram and 670ppm maximum at Marteru with an average of 296ppm. Potassium values are high at Gollagunta, Marteru, Neggipudi and Kavitam. The minimum value 16ppm is observed at Toorpu Vipparru and maximum 240ppm at Neggipudi with an average of 88ppm. Chloride values are high and crossed the permissible limits at Peravali, Neggipudi, Marteru and Jinnuru. The value 99.26ppm is minimum at Gollagunta and maximum 389.95ppm at Jinnuru with an average of 216.56ppm.

Table.6. Narsapur Canal Area Treated Water (Surface water) - 1st Phase

Village	PH	TDS (ppm)	EC ($\mu\text{s}/\text{cm}$)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Panditha Valluru	8.10	150	220	90	80	0.1	0.01	0.03	2.50	33	3	52.78
Poduru	8.62	130	180	90	120	5.7	0.15	0.02	3.50	30	2	90.87
Vedangi	8.07	200	290	100	120	1.0	0.01	0.01	10.9	37	12	42.57
Penumantra	7.97	150	230	85	90	3.2	0.10	0.01	12.6	28	3	56.76
Uilamparru	8.27	160	240	85	110	0.9	0.01	0.02	11.21	37	4	42.57
Palakollu	8.50	150	230	80	90	0.9	0.01	0.02	2.80	29	2	40.05
Chandaparru	8.03	300	430	130	140	0.6	0.01	0.02	1.20	62	3	127.7
Gorintada	8.17	270	400	115	155	0.3	0.01	0.01	17.7	60	3	70.9
Digamarru	8.09	220	330	105	120	4.1	0.01	0.12	13.3	46	2	56.76
Chittavaram	8.29	160	240	165	110	2.9	0.02	0.06	1.40	31	3	42.57
Narsapuram	7.71	150	210	80	80	0.4	0.01	0.02	0.80	29	3	56.76
Mogalturu	8.34	230	340	100	110	1.2	0.01	0.02	11.7	53	3	72.9
Average	8.18	189	278	102	110	1.7	0.03	0.03	7.46	37	3	62.80

As shown in the table the treated surface water PH is on the higher side in most of the villages and even crossed the permissible limit in Poduru. The minimum value is 7.71 in Narsapur and maximum 8.62 in Poduru with an average of 8.18. The TDS and EC values are well within the permissible range with minimum value 130ppm at Poduru and maximum 300ppm at Chandaparru with an average of 189ppm ; and similarly EC value minimum 180 $\mu\text{s}/\text{cm}$ at Poduru and maximum 430 $\mu\text{s}/\text{cm}$ at Chandaparru with an average of 278 $\mu\text{s}/\text{cm}$. Total hardness is also within the permissible limit with minimum 80ppm at Palakollu and Narsapur municipal waters and maximum 165ppm at Chittavaram with an average of 102ppm. Alkalinity values are ranged from 80ppm to 155ppm with an average of 110ppm and all values are within the permissible limits. Turbidity values are also below the permissible limit except in Poduru. The minimum value of turbidity is 0.1 NTU observed at Panditha Valluru and maximum 5.70NTU at Poduru with an average of 1.7NTU. The Ammonia, nitrite and nitrate values are well below the permissible limits. Sodium values are also low with minimum 28ppm at Penumantra and maximum 62ppm at Chandaparru with an average of 37ppm. Potassium values are very low and negligible. Chloride values vary from 40.05ppm at Palakollu to 90.87ppm at Poduru with an average of 62.80ppm.

Table.7. Public Treated Water of Narsapur canal area-2nd phase

Village	PH	TDS (ppm)	EC ($\mu\text{s}/\text{cm}$)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Pandithavalluru	8.51	210	300	90	70	3.3	0.04	0.01	4.98	120	6	177.25
Poduru	8.35	160	230	80	60	3.0	0.01	0.02	3.21	15	17	134.71
Vedangi	7.86	230	330	100	60	3.8	0.00	0.00	3.06	11	18	127.62
Penumantra	8.20	170	250	160	60	2.8	0.01	0.01	3.89	29	1	98.56
Uilamparru	8.30	190	280	100	60	2.9	0.00	0.00	2.50	32	2	99.26
Palakollu	8.40	200	290	100	50	2.1	0.00	0.00	3.03	19	1	155.98
Chandaparru	8.20	330	470	100	80	2.7	0.01	0.00	7.55	47	3	185.08
Gorintada	8.30	380	550	100	70	2.6	0.00	0.00	4.75	74	4	141.80
Digamarru	8.20	440	650	130	85	2.4	0.00	0.00	4.68	82	3	368.68
Chittavaram	8.40	240	360	90	80	3.2	0.00	0.00	3.89	23	1	106.35
Narsapuram	8.40	180	260	100	60	1.8	0.01	0.01	4.15	19	1	127.62
Mogalturu	8.60	420	600	190	80	2.2	0.01	0.00	5.38	91	1	127.62
Average	8.30	262	380	111	67	2.73	0.006	0.003	4.25	46	4.8	154.26

As shown in the table the Public treated water in the second phase has more PH than first phase and even crossed the permissible limit at Panditha Valluru and Mogalturu. The minimum pH value is 7.86 at Vedangi and maximum 8.60 at Mogalturu with an average of 8.30. The TDS and EC values are also increased over the first phase but within the permissible limits. The TDS values ranged from 160ppm at Poduru to 440ppm at Digamarru village with an average of 262ppm. Similarly EC value is minimum 230 $\mu\text{s}/\text{cm}$ at Poduru and maximum 650 $\mu\text{s}/\text{cm}$ at Digamarru with an average of 380 $\mu\text{s}/\text{cm}$. The Total hardness value is 80ppm at Poduru and maximum 190ppm at Mogalturu with an average of 111ppm. Alkalinity values are low and further decreased when compared to first phase. The minimum value is 50ppm at Palakollu and maximum 85ppm at Digamarru with an average of 67ppm. Turbidity, ammonia, nitrites and nitrates are low and well below the permissible limits. Sodium minimum value is 11ppm at Vedangi and maximum 120ppm at Panditha Valluru with an average of 46ppm are well below the permissible limit. Potassium values are low and negligible. Chlorides are within the permissible range except at Digamarru. The

chloride value is minimum with 98.56ppm at Penumantra and maximum 368.68ppm at Digamaru with an average of 154.26ppm.

Table.8. Comparison of treated water surface water samples, two seasons

S.No	PH	TDS (ppm)	EC (µs/cm)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Phase-1	8.18	189	278	102	110	1.70	0.03	0.03	7.46	37	3.0	62.80
Phase-2	8.30	262	380	111	67	2.73	0.006	0.003	4.25	46	4.8	154.26

The treated water has more TDS and EC values because of the addition of alum as coagulant and chlorination for disinfection. The values of PH, TDS, EC, TH, Turbidity, Hardness, Sodium, Potassium and Chlorides are increased in comparison to first season. This variation is in same lines of the raw water samples of two seasons. The values of alkalinity, ammonia, nitrites and nitrates are decreased again matching the values of the raw water samples of the two seasons.

Table.9. Narsapur canal Area Treated Water (Under Ground Water)-1st Phase

Village	PH	TDS (ppm)	EC (µs/cm)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Ajjaram	7.85	720	1030	440	350	0.7	0.01	0.06	7.4	83	7	110.53
Peravali	8.14	820	1170	320	380	0.4	0.01	0.01	6.7	142	12	160.30
Kottapalli	8.02	860	1230	320	430	0.4	0.48	2.40	35.0	135	23	110.04
Kapavaram	7.74	950	1360	370	405	0.5	0.01	0.04	25.0	121	77	145.00
Toorpuviparru	8.28	640	920	330	230	0.4	0.01	0.01	11.8	96	22	54.25
Kakulallindaparru	8.30	970	1390	420	500	0.2	0.02	0.02	15.8	166	47	62.40
Surampudi	7.68	630	900	200	250	0.2	0.01	0.02	52.3	98	114	45.42
Rapaka	7.64	360	520	250	450	0.4	0.01	0.03	15.0	46	12	42.51
Gollagunta	8.00	390	560	210	410	1.2	0.02	0.01	9.6	119	8	31.24
Aitampudi	7.90	680	970	310	350	0.3	0.01	0.02	10.9	107	43	80.56
Penugonda	7.40	830	1190	410	450	0.4	0.02	0.02	65.3	134	9	61.12
Mallapudi	8.20	760	1090	470	430	1.0	0.08	0.31	4.5	168	4	52.45
Venkataramapuram	8.24	760	1090	430	450	0.6	0.10	0.31	20.9	166	4	156.65
Neggipudi	8.28	920	1320	440	440	0.3	0.01	0.02	3.80	135	18	53.89
Marteru	8.24	920	1320	320	430	0.6	0.18	0.02	3.30	146	12	52.45
Kavitam	8.23	940	1350	210	440	0.4	0.01	0.02	2.10	162	7	74.21
Jinnuru	8.14	1130	1620	325	520	0.4	0.10	0.03	9.60	145	58	255.4
Agaru	8.02	390	560	145	125	2.0	0.01	0.02	11.89	79	3	80.90
Average	8.01	759	1088	328	391	0.58	0.11	0.18	17.27	125	26	90.51

In case of ground water PH is less than surface water with minimum 7.40 at Penugonda and maximum 8.30 at Kakula illinda parru with an average of 8.01. All the PH values are within the limits of drinking water standards. The TDS values of treated water are higher than raw water and crossed the 500ppm mark at all the points except Agarru, Gollagunta and Repaka with a minimum of 360ppm at Repaka and maximum of 1130 ppm at Jinnuru with an average of 759ppm. Correspondingly EC value is minimum with 520µs/cm and maximum 1620µs/cm with an average of 1088µs/cm. Total hardness is also increased and crossed the standard of 300ppm at all the points except Agarru, Kavitam, Gollagunta, Repaka and Surampudi due to addition of bleaching powder for disinfection. The minimum hardness value is 145ppm at Agarru and maximum 470ppm at Mallapudi with an average of 328ppm. Alkalinity values are increased and crossed the permissible limit except at Agarru, when compared to raw water and the minimum value is 125ppm at Agarru and maximum 520ppm at Jinnuru with an average of 391ppm. Turbidity values are decreased than the raw water and are within the permissible limits. Ammonia and nitrite values are negligible except Kottapalli and Marteru where the ammonia values are higher than the permissible limits. Nitrates are increased and crossed the permissible limit at Surampudi and Penugonda ground water samples. The minimum value is 2.10ppm at kavitam and 65.3ppm at Penugonda with an average of 17.27ppm. All the sodium values are within the permissible limits with minimum value 46ppm at Repaka and maximum 166ppm at Mallapudi with an average of 125ppm. Potassium values are ranged from 3ppm at Agarru to 114ppm at Surampudi with an average of 26ppm. Chloride values are within the range except at Jinnuru with the minimum value of 31.24ppm at Gollagunta and maximum of 255.40ppm at Jinnuru with an average of 90.51ppm.

Table.10. Public Treated ground water-2nd phase

Village	PH	TDS (ppm)	EC (µs/cm)	TH (ppm)	TA (ppm)	Turb. (NTU)	NH ₃ (ppm)	NO ₂ (ppm)	NO ₃ (ppm)	Na (ppm)	K (ppm)	Cl (ppm)
Ajjaram	7.80	740	1050	460	270	5.0	0.01	0.00	12.24	134	18	184.34
Peravali	8.00	870	1240	210	260	5.2	0.00	0.00	4.12	520	20	262.33
Kotthapalli	8.51	850	1210	330	340	4.1	0.23	2.85	2.46	310	30	155.98
Kapavaram	8.25	950	1360	320	140	5.1	0.11	0.12	35.09	90	30	241.06
Thorpu Viparru	8.73	700	1000	400	200	5.0	0.01	0.00	30.20	181	16	205.61
Kakula-illindaparru	8.50	720	1030	70	50	4.6	0.00	0.29	9.56	190	16	106.35
Surampudi	8.30	290	410	200	100	4.1	0.00	0.00	3.97	58	16	85.08
Rapaka	7.70	300	430	170	140	3.7	0.00	0.00	12.11	37	20	99.26

Gollagunta	8.54	460	660	160	220	5.1	0.00	0.00	1.10	230	160	99.26
Aitampudi	7.36	830	1180	310	320	4.3	0.00	0.00	30.7	200	50	212.70
Penugonda	8.50	900	1280	340	180	4.0	0.00	0.02	11.97	420	190	219.79
Mallapudibba	8.39	880	1260	100	400	2.2	0.04	0.01	0.73	106	200	269.24
Venkataramapuram	7.92	910	1300	110	350	2.3	0.02	0.72	5.21	230	260	106.35
Neggipudi	8.45	990	1410	360	310	3.1	0.01	0.00	5.41	460	240	262.33
Marteru	8.48	960	1370	270	310	4.0	0.01	0.00	1.06	670	190	269.42
Kavitam	8.30	800	1140	190	200	4.0	0.01	0.01	2.78	330	230	205.61
Bolletigunta	8.45	160	210	80	70	2.4	0.00	0.00	2.88	8	15	106.35
Jinnuru	8.15	1190	1700	350	250	2.8	0.00	0.00	2.98	141	20	389.95
Average	8.24	750	1068	246	228	3.9	0.02	0.22	9.68	152	95	193.38

In case of treated ground water PH is less than surface water in both the phases. The minimum value of PH is 7.36 at Aitampudi and maximum 8.73 at Toorpu Vipparru with an average of 8.24. The TDS values are minimum 160ppm at Bolletigunta and maximum 1190ppm at Jinnuru with an average of 750ppm, and correspondingly EC values are minimum 210 μ s/cm and maximum 1700 μ s/cm with an average of 1068 μ s/cm. total hardness value is minimum 70ppm at Kakula illindaparru and maximum 1410ppm at Neggipudi with an average of 246ppm. The alkalinity values are minimum 50ppm at kakula illindaparru and maximum 400ppm at Mallapudibba with an average of 228ppm. Turbidity values are minimum 2.2NTU at Mallapudibba and maximum 5.2NTU at Peravali with an average of 3.9NTU. Ammonia values are negligible except at Kottapalli with 0.23ppm and Peravali 0.11ppm. Nitrites values are also negligible except at Kottapalli with the value 2.85ppm. Nitrate values ranged from 0.73ppm at Mallapudibba to 35.09ppm at kapavaram with an average of 9.68ppm. Sodium values are varied from minimum 8.0ppm at Bolligunta to 670ppm at Marteru with an average of 152ppm. Potassium values are high with minimum 15ppm at Bolligunta to 260ppm at Neggipudi with an average of 95ppm. Chloride values are ranged from 85.08ppm at Surampudi to 389.95ppm at Jinnuru with an average of 193.38.

Table.11. Comparison of Averages of Physico-chemical parameters in two seasons

Source	Canal-1	Canal-2	G.W-1	G.W-2	P.T.W-1 (S.W)	PTW-2 (S.W)	PTW 1 (GW)	PTW 2 (GW)
PH	8.40	8.49	8.14	8.33	8.18	8.30	8.01	8.24
TDS	137	170	712	1034	189	278	759	820
EC	199	244	839	1197	262	380	1088	1162
TH	85	104	247	342	102	111	328	354
TA	86	72	283	231	110	67	391	374
Turb.	0.70	4.80	0.83	4.30	1.70	2.73	0.58	3.90
NO ₃	13.2	3.10	27.5	9.70	7.46	4.25	17.27	20.76
Na	31	22	114	296	37	46	125	136
K	2.0	9.6	12	88	3.0	4.8	26	19
Cl	35	113	97	216	62.8	154.2	90	193

The above table summarizes the average results of canal waters, ground waters and Public treated water of two seasons. TDS, EC, Hardness, Sodium, Potassium and chloride values of Ground waters particularly in the second season have higher values than surface waters. Alkalinity and nitrate values of ground water in first season are more than the second season. Turbidity of canal water is more than ground water.

Table.12. Microbiology of Narsapur canal Area Treated Water (Under Ground Water)

Name of the village	MPN/100ml	TFC/100ml	<i>E.coli</i> /1ml
Ajjaram	460	23	112x10 ²
Peravali	9	0	0
Kottapalli	≥2400	0	253x10 ²
Kapavaram	9	0	0
Toorpuvipparru	0	0	0
Kakulaillindaparru	0	0	0
Gollagunta	0	0	0
Aitampudi	23	23	67x10 ²
Neggipudi	≥2400	0	186x10 ²
Marteru	0	0	0
Pandithavalluru	460	210	147x10 ²
Kavitam	0	0	0
Poduru	≥2400	460	117x10 ²
Vedani	≥2400	93	2x10 ²
Golletigunta	≥2400	240	32x10 ²
Penumantra	0	0	0

Jinnuru	≥2400	460	115x10 ²
Uilamparru	1100	210	0
Palakollu	0	0	0
Chandaparru	≥2400	1100	146x10 ²
Aagarru	≥2400	23	0
Gorintada	≥2400	23	0
Digamarru	≥2400	23	0
Chittavaram	≥2400	150	2x10 ²
Narsapuram	0	0	0
Sitaramapuram	0	0	0
Mogalturu	6	0	0
Mori	0	0	0

Based on MPN values drinking water in most of the places like Ajaram, Kottapalli, Neggipudi, Poduru, Vedangi, Golligunta, Jinnuru, Uilamparru, Chandaparru, Aagarru, Pandithavalluru, Gorintada, Digamarru and Chittavaram is not at all suitable for drinking. In Peravali, kapavaram, Aitampudi the water is suitable by taking proper care in chlorination. Whereas potable water is supplied in Toorpu Viparru, Kakula illindaparru, Gollagunta, Marteru, Kavitam, Penumantra, Palakollu, Narsapuram, Sitaramapuram and Mori.

Table.13. Results of MPN/100ml, TFC/100ml and *E.Coli*/1ml off Treated water

Parameter	NIL	>50	< 50	Total samples
MPN/100ml	9 (32.1%)	4 (14.3%)	15 (53.6%)	28
TFC/100ml	15(53.6%)	5 (17.9%)	8 (28.5%)	28
E.Coli/1ml	17(60.7%)	0(0%)	11(39.3%)	28

Table.14. Microbiological Parameters of Public treated water of Narsapur canal area-2nd phase

Village	MPN/100ml	TFC/100ml	<i>E.Coli</i> /1ml
Ajaram	0	0	0
Peravali	0	0	0
Kotthapalli	0	0	0
Kapavaram	93	7	0
Thorpu Viparru	47	9	0
Kakula-illindaparru	0	0	0
Surampudi	0	0	0
Rapaka	0	0	0
Gollagunta	43	0	0
Aitampudi	43	23	4x10 ²
Penugonda	460	210	36x10 ²
Mallapudibba	0	0	0
Venkataramapuram	0	0	0
Neggipudi	240	150	5x10 ²
Marteru	0	0	0
Pandithavalluru	93	0	0
Kavitam	150	15	0
Poduru	460	0	0
Vedangi	64	0	0
Bolletigunta	460	460	0
Jinnuru	93	23	0
Penumantra	0	0	0
Uilamparru	≥2400	≥2400	76x10 ²
Palakollu	0	0	0
Chandaparru	0	0	0
Aagarru	150	43	0
Gorintada	290	150	14x10 ²
Digamarru	0	0	0
Chittavaram	0	0	0
Narsapuram	0	0	0

Sitaramapuram	≥2400	93	21x10 ²
Mogalturu	460	39	7x10 ²
Modi	43	23	0

In the second phase based on MPN the drinking water not suitable for drinking are Kapavaram, Penugonda, Neggipudi, kavitam, Poduru, Bolligunta, Uillamparru, Aagarru, Goritada, Sitaramapuram and Mogalturu. The villages that may be suitable if proper care is taken for chlorination are Kapavaram, Toorpu Vipparru, Gollagunta, Atampudi, Panditha Valluru, Vedangi, Jinnuru and Modi. The water that is suitable for drinking is available at Ajjaram, Peravali, Kottapalli, Kakula Illindaparru, Repaka, Mallapudibba, marteru, Penumantra, Palakollu, Chandaparru, Digamarru, Chittavaram and Narsapur.

Table.15. Results of MPN/100ml, TFC/100ml and E.Coli /1ml off Treated water

Parameter	NIL	>50	< 50	Total samples
MPN/100ml	15(45.5%)	4(12.1%)	14 (42.4%)	33
TFC/100ml	19(57.6%)	8(24.2%)	6(18.2%)	33
E.Coli/1ml	26 (78.8%)	-	7(21.2%)	33

3. CONCLUSION

Water supply schemes and sanitation are considered as one of the most important entity in the rural and urban infrastructure system. The inherent problem associated with the water supply schemes is lack of proper monitoring throughout the network and this leads to insufficient supply to serve the requirement of increase in population. The observed quality of treated surface water and groundwater in the region of Narsapur canal area, West Godavari District, Andhra Pradesh shows that the clean water source by the national government, WHO and BIS 10500 drinking water guidelines are exceeded at water supply stations in the selected study sites of the West Godavari Western Delta for pH, turbidity, Cl⁻, MPN, *E. coli*, and total coli forms. In treated Surface water samples, during summer season the values of pH, TDS, EC, TH, TA, Turbidity, Nitrate, BOD, Sodium and Potassium levels were increased. COD values in both surface and groundwater samples the levels were increased in summer season when compared to that of winter season. The bacterial counts were found beyond the permissible range and water was unsuitable for drinking. Strict control and appropriate management of the distribution system is recommended for the prevention of the contamination.

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REFERENCES

- APHA, Standard Methods for the Examination of Water and Waste Water, 21st Edn., Washington D.C, 2005.
- Banerjea S.M, Water Quality and Soil Condition of Fishponds in States of India in Relation to Fish Production, Indian Journal of Fisheries, 14 (1&2), 1967, 115-144.
- Chisty N, Studies On Biodiversity Of Freshwater Zooplankton In Relation To Toxicity Of Selected Heavy Metals, Ph. D. Thesis Submitted To M.L Sukhadia Univeristy, Udaipur, 2002.
- Dagaonkar A, Saksena DN, Physico-Chemical and Biological Characterization of Temple Tank, Kaila Sagar, Gwalior, Madhya Pradesh, J. Hydrobiol. 8 (1), 1992, 11-19.
- Damotharan P, Permal NV, Perumal P, Seasonal Variation of Physico-Chemical Characteristics of Point Calimere Coastal Waters (South East Coast of India), Middle-East Journal of Scientific Research, 6 (4), 2010, 333-339.
- Devaraju TM, Venkatesha MG, Singh S, Studies on Physico-Chemical Parameters of Muddur Lake with Reference to Suitability for Aquaculture, Nat. Environment and Pollution Technology, 4, 2005, 287-290.
- Garg RK, Saksena DN, Rao RJ, Assessment of Physico-Chemical Water Quality of Harsi Reservoir, District Gwalior, Madhya Pradesh, Journal of Ecophysiology and Occupational Health, 6, 2006, 33-40.
- Ghassemi F, Jakeman A.J, Jacobson G, & Howard K.W.F, Simulation of seawater intrusion with 2D and 3D modes: Nauru Island case study, Hydrogeology Journal, 4 (3), 1996, 4-22.
- Hujare M.S, Seasonal Variation of Physico-Chemical Parameters in the Perennial Tank of Talsande, Maharashtra, Ecotoxicology and Environmental Monitoring, 18 (3), 2008, 233-242.
- Jayaraman PR, Ganga DT, Vasudevan NT, Water Quality Studies on Karamana River, Thiruvananthapuram District, South Kerala, India, Pollution Research, 22 (1), 2003, 89-100.

Kadam M.S, Pampatwar D.V, and Mali R.P, Seasonal Variations In Different Physico-Chemical Characteristics in Mosoli Reservoir of Parbhani District, Maharashtra, Journal of Aquatic Biology, 22 (1), 2007, 110-112.

Khan M.A.G & Choudhary S.H, Physical and Chemical Limnology of Lake Kaptai: Bangladesh, Tropical Ecology, 35 (1), 1994, 35-51.

Kirubavathy AK, Binukumari S, Mariamma N, Rajammal T, Assesment of Water Quality of Orthupalayam Reservoir, Erode District, Tamil Nadu, Journal of Ecophysiology and Occupational Health, 5, 2005, 53-54.

Kodarkar M.S, Diwan A.D, Murugan N, Kulkarni K.M, and Anuradha Remesh, Methodological Water Analysis (Physico-Chemical, Biological and Microbiological), I.A.A. B. Publication, Hyderabad, 1998.

Prasanna M, Ranjan P.C, Physico-Chemical Properties of Water Collected from Dhamra Estuary, International Journal of Environmental Science, 1 (3), 2010, 334-342.

Wurbs R.A, & James W.P, Water resources engineering, Prentice Hall, 2002.