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Yanamadurru Drain Water Quality Assessment during 12-13 March, 2016

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----------ABSTRACT----------
The south foot of hill ranges on north side of West Godavari District is the birth of Yerrakaluva, within few kilometers in down stream, a reservoir constructed near Konguvarigudem. Yerrakaluva ends up at Duvva Village to Yanamadurru drain separated by a weir. Yanamadurru acts as a drain for discharging waste water from the fields and ends by confluence with Upputeru at Naidupalem. On upstream of Yanamadurru drain from Bhemavaram village, River Gasthani confluenced with this Drain. River Gosthani and Yanamadurru drain downstream from Garagaparru influenced with industrial discharges, municipal sewage, aqua culture waste discharges and causing pollution nuisance to the people adjacent to Bhimavaram Town. The stretch of Yanamadurru drain is surveyed with water sample collections and found that the drain water, from its starting point is meeting drinking water standards crossed the limit acceptable of 500mg/L TDS at Peppara and further deterioration found and exceeded permissible limit of 2100mg/L at Garagaparru before confluence of River Gosthani. The COD and BOD concentrations are reached 116 and 42mg/L further increased when crossing Bhimavaram Town due to sewage and MSW joins to Yanamadurru drain.

Keywords: *Yanamadurru drain, River Goasthani, Yerrakaluva, Veyyuru canal,Kalipatnam canal.*

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I. INTRODUCTION

Based on the complaint regarding pollution of Yanamadurru drain, the Chairman, APPCB had entrusted assessment of water quality to the Joint Chief Environmental Scientist, I/C (JCES). In obedience he proceeded to Visakhapatnam for feedback from the JCEE, formed a team with the SES, an Analyst Gr-I and a Field-man from the Zonal Laboratory, Visakhapatnam on 11.03.2016 and conducted survey, sampling and field monitoring on 12.03.2016 and 13.03.2016. Water Samples Analysis is done at Zonal Laboratory, Visakhapatnam. The JCES prepared report with association of Analyst by processing the Analysis reports and field observations. On upstream of Yerrakaluva near the south foot of hill ranges on north side of West Godavari District, Yerrakaluva Reservoir constructed near Kanguvarigudem village and downstream point ends with Yanamadurru Channel at Duvva village. Yanamadurru drain water is used for lift irrigation of paddy fields and drain flood water from the cultivated fields (paddy, Aqua culture fields). Yanamadurru drain/channel is around 61.2 KM length up to confluence of Upputeru. It is also called as Veyyuru canal up to confluence point of River Gosthani at Gollalakoderu. Yanamadurru drain is in the web of agriculture drains originated from Dowaleswaram anicut on River Godavari, intended for discharge of wastewater and floodwater from these fields. Hence it has many inlets with control to prevent back flow from these fields and canals.

II. SURVEY AND MONITORING

The team on 12.03.2016 reached Duvva village and started survey, water sampling along the bund of Yanamadurru drain. Water samples are referred 'S' series (S1-18) and Photographs at critical points and observations are referred X series (X1-31) as detailed at TABLE 1. Photographs are placed at Fig. 1-3, GPS data collected with the aid of smart phone "CoolpadNote3" and GPS mapping is done with the aid of "ViewNX2" software provided with camera "Nikon CoolpixP520". There is some uncertainty in lat-long data as it is from GPS through smart phone for serving approximate indication of position.

Water Sample collected from Yerrakaluva downstream at Duvva village (S1, X2) and it is called Yanamadurru drain separated by a weir. The next Yanamadurru drain water sample collected at a bridge near Menavalluru village (S2, X3) where Arudalakodu (A confluence of combination of some drains) joined through a weir and culvert in upstream. Then the team observed that water is joining through culvert to the Yanamadurru

drain at upstream of a bridge at Pippera village. Water sample collected near Bridge, Pippera from Yanamadurru drain (S3, X5) where local farmers are using diesel motors for lifting water from the drain. Water sample collected near bridge, Kesavaram village from Yanamadurru drain (S4, X6). In the downstream from Kesavaram Village there is one more bridge (X6), observed aqua culture farm fields draining rejects through pipe line in to Yanamadurru drain and collected water sample from pipeline (S5, X7, X8). Later, near subway at S.Kongepadu, water sample is collected from Yanamadurru drain (S6, X9). After crossing a culvert (X10), there is a Bridge at Yandagandi (X11) and proceeds to a Bridge, Garagaparru. A water sample is collected at the Bridge, Garagaparru from Yanamadurru drain (S7, X12). Photographic views of Yenamadurru stretch from Bridge, Duvva to Bridge, Garagaparru are covered in X1-12 are at Fig. 1.

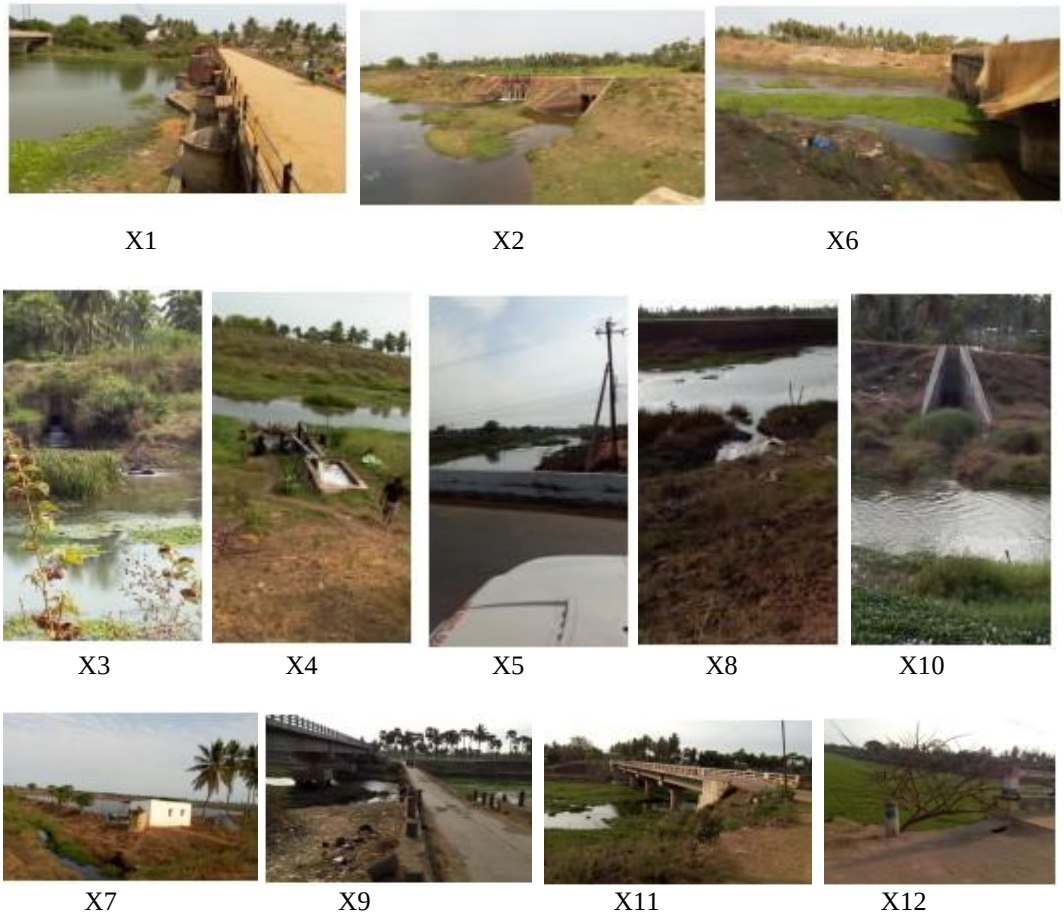
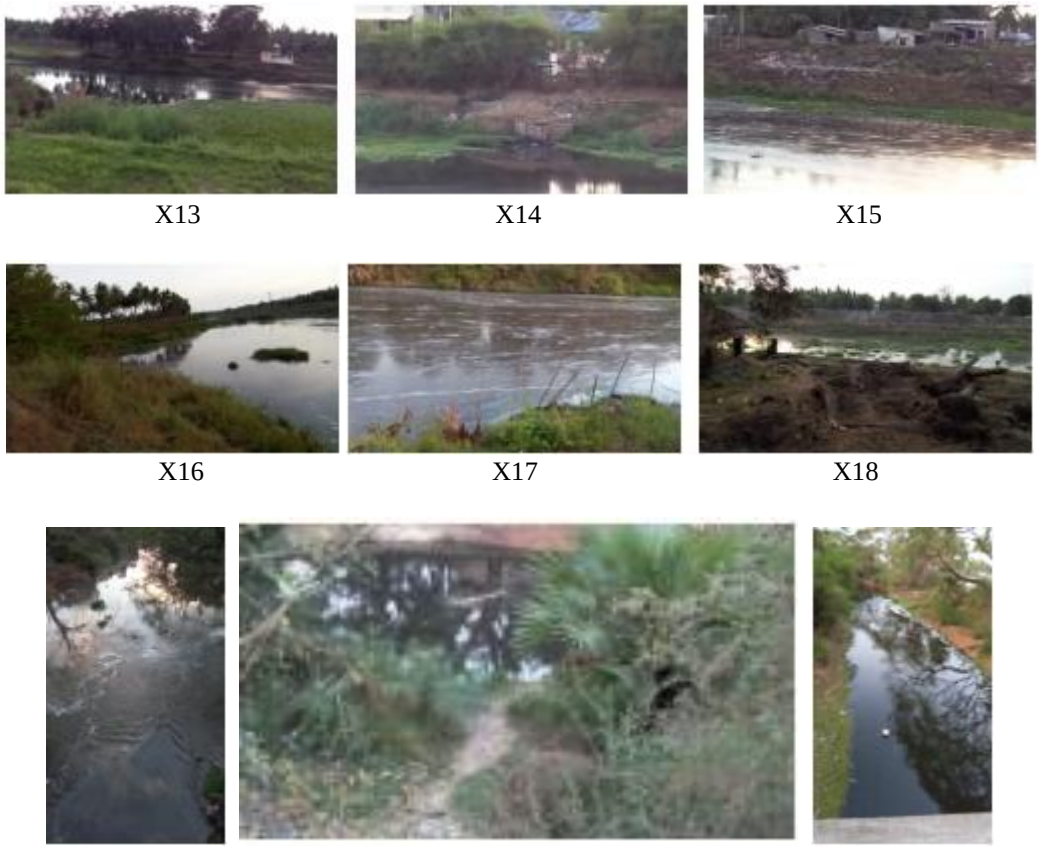


Fig. 1: Photographic views of Yenamadurru stretch from Bridge, Duvva to Bridge, Garagaparru (X1-12)

There is sudden change in the color, suspended and floating matter and municipal garbage found inside the bank of Yanamadurru drain in downstream from Bridge, Garagaparru. In the downstream, water sample is collected at Farmers Welfare Society Lift Irrigation Point (S8, X13) and observed on the opposite bank, there is covered pipe line joining Yanamadurru drain (X14). Down to it, oily surface on drain water is observed and garbage waste is being dumped inside the bund of Yanamadurru drain. While moving forward, it is observed that prawn processing units on opposite bund edge of Yanamadurru drain, processed aqua solid waste rejects are found inside bank with foul smell (X15). The confluence point of River Gosthani is reached (X16). Water Sampling is done at River Gosthani before its confluence with Yanamadurru drain (S9, X16) used for agricultural lift irrigation. Then the team reached Yanamadurru drain after confluence with River Gosthani at Palakoderu and collected sample (S10, X18) from lift irrigation point in the downstream near Gollalakoderu Village Bridge. The team moved on the bank of River Gosthani, before confluence with Yanamadurru drain, collected water sample near bridge (S11, X19), after confluence with M/s. Delta paper Mills effluents and is used for agriculture purpose with lift irrigation. It crossed M/s. Delta paper Mills, Vendra village treatment facility, collected sample on upstream before confluence of M/s. Delta paper Mills effluents and it is the point after confluence of aqua culture effluents (S12, X20). Then, the team moved towards upstream of River Gosthani and found aqua culture fields discharging rejects to the river and samples are collected on upstream of

this confluence point in the River Gosthani (S13, X21). Photographic views of Yenamadurru stretch from farmer's welfare lift irrigation pump, Garagaparru to lift irrigation Pump at Palakoderu and the stretch of River Gosthani up to Vendra from confluence with Yanamaduru drain are covered in X13-21 are at Fig. 2.



X13 X14 X15

X16 X17 X18

X19 X20 X21

Fig. 2: Photographic views of Yenamadurru stretch from Garagaparru to Palakoderu and stretch of River Gosthani up to Vendra from confluence with Yanamaduru drain.

On 13.3.2016, the team consulted complainant Mr. Ansari, Secretary Consumer Welfare Protection Society, Bhimavaram Town and his associates for collecting opinions. They informed that the people including him suffered from unbearable foul smell emanate from Yanamadurru drain in the city area. He opined that, it would be from the industries discharges. He and the members of his society opined that a dedicated pipe line for industrial discharges into sea would be a remedy for the problems they are facing and expressing their willingness of contribution in some extent.

Later, the team continued survey on bank of Yanamadurru drain downstream from Bhimavaram Town. Sample is collected near Prakasam chowk (S14, X22), then reached to Government hospital road and collected sample near footpath bridge connecting 1 and 2 towns of Bhimavaram (S15, X23). It reached Bhimavaram lakulu connecting Kalipatnam canal (agriculture) and collected sample from Yanamadurru drain (S16, X24). Then it reached Yanamadurru village and collected sample from Yanamadurru drain (S17, X25). It finally proceeds to Naidupalem before confluence point of Upputeru and collected samples from the Yanamadurru drain (S18, X26). Photographic views of Yenamadurru drain stretch from Prakasam chowk, Bhimavaram to Upputeru, Naidupalem are covered in X22-26 at Fig. 3. The samples details referred as S1-18 are placed at column 2 and Photographs X1–26 are referred at column 1 TABLE 1.

X22 X23 X24

X25 X26

Fig. 3: Photographic views of Yenamadurru drain stretch from Prakasam chowk, Bhimavaram to Upputeru, Naidupalem.

Table 1: Sample location / Photographic View Point Description (location)

View point	Sample Code	Sample location / Photo View Point Description (location)	Latitude N	Longitude E
X1	S1	Yanamadurru drain water collected at weir (Lakulu), Duvva (V)	16°46'51.8"	81°37'20.6"
X2	S2	Yanamadurru drain water collected at Bridge- Meenavalluru (V) and a view of Arudalakodu (a set of drains) joining through weir and culvert in upstream.	16°44'10.8"	81°35'26.3"
X3		water is joining through culvert to the Yanamadurru drain at upstream of a bridge at Pippera village	16°40'58.6"	81°36'23.6"
X4	S3	Yanamadurru drain water collected near Bridge- Pippara (V) and a view in upstream, water joining through a culvert.	16°46'51.8"	81°37'20.6"
X5	S4	Yanamadurru drain water collected near Bridge- Kesavaram (V) views of Yanamadurru drain near Kesavaram Bridge	16°41'26.3"	81°32'20.0"
X6		In the downstream from Kesavaram Village there is one more bridge	16°40'46.9"	81°32'19.5"
X7, X8	S5	Yanamadurru drain water collected near fish/prawn cultivation, hatcheries point (at the point waste water is discharged through pipe line into drain) near Kesavaram (V)	16°40'29.7"	81°32'16.9"
X9	S6	Yanamadurru drain water collected at Bridge near Subway, S.Kongepadu (V)	16°46'51.8"	81°37'20.6"
X10, X11		Culvert and Bridge at Yandagandi	16°38'52.4"	81°32'6.8"
X12	S7	Yanamadurru drain water collected at Bridge (Abundant quantity of municipal solid waste was observed on the bunds) – Garagaparru (V)	16°36'58.2"	81°32'15.0"
X13	S8	Yanamadurru drain sample collected B/C of Gosthani river at farmers welfare society lift irrigation point – Garagaparru (V)	16°35'26.4"	81°32'16.0"
X14, X15		Pipe line joining Yanamadurru drain near Garagaparru Village. Down to it processed aqua solid waste reject found inside bank and observed foul smell	16°36'58.2"	81°32'15.0"
X16		The confluence point of River Gosthani	16°36'17.8"	81°32'8.5"
X17	S9	River Gosthani sample collected B/C of Yanamadurru drain- Garagaparru (V)	16°35'35.4"	81°32'18.8"
X18	S10	Yanamadurru drain sample collected after confluence with river Gosthani- Palakoderu (V). A view of sampling point at lift irrigation through pipeline	16°34'41.4"	81°32'15.4"
X19	S11	Gosthani river water collected after the confluence point of M/s. Delta Paper Mills 16°46'51.8"effluent – Vendra (V). A view at bridge on River Gosthani.	16°33'51.3"	81°34'10.3"
X20	S12	Gosthani river water collected before the confluence point of M/s. Delta Paper Mills effluent and after confluence of Aqua culture effluents – Vendra (V).	16°33'51.3"	81°34'10.3"
X21	S13	Gosthani river water collected before the confluence point of Aqua culture effluents – Vendra (V). Views of River	16°33'51.3"	81°34'10.3"

		Gosthani at aqua culture fields		
X22	S14	Yanamadurru drain samples collected at Yanamadurru Bridge of Bhimavaram Town near Prakasham Chowk – Bhimvaram (V)	16°32'32.8"	81°31'7.0"
X23	S15	Yanamadurru drain samples collected at foot path Bridge near Govt. Hospital, Bhimavaram connected first and second towns – Bhimavaram (V)	16°32'51.8"	81°31'7.0"
X24	S16	Yanamadurru drain samples collected at Bhimavaram Lakulu, D/s. of Bhimavaram Town B/C point of Kalipatnam Canal and Photographic views	16°32'39.7"	81°31'5.8"
X25	S17	Yanamadurru drain samples collected at Yanamadurru Village and view of the drain.	16°29'0.7"	81°31'4.3"
X26	S18	Yanamadurru drain samples collected at Naidupalem Bridge – Naidupalem (V), before the confluence with Upputeru. The photograph for referring lat-long.	16°23'50.8"	81°28'33.2"

III. LABORATORY ANALYSIS

Laboratory Analysis consisting of physico-chemical analysis at the Laboratory for (i) Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and Dissolved Oxygen (DO); (ii) estimation of inorganic ionic concentrations of Sodium, Potassium, Calcium, Magnesium, Chloride, Sulphate, Carbonate, Bicarbonate, Ammonium, Nitrate, Nitrite, Phosphate, Boron, Fluoride and Heavy metals. Standard Operating Procedures (SOPs) are followed [1, 2]. SOPs were prepared and upgraded from time to time based on the methods of i) APHA (American Public Health Association), 16th (1985), 20th (1998) and 21st Edition (2005): titled "Standard Method for Examination of water and wastewater", ii) "Guide Manual: Water and Wastewater Analysis" published by the CPCB, New Delhi, iii) Indian Standard (IS) methods as mentioned against parameter. Checking Correctness of Analysis [3, 4] include pH, EC, TDS and major anionic and cationic constituents that are indications of general water quality.

TABLES 2–3 show irrigation hazardous water quality rating (Ir. HWQR) [5] based on hazardous effects on plants and Limits of parameters as per BIS/ Guidelines for Quality of Irrigation Water IS 11624 (1986) modified in 2006 and comparable for drinking water standards IS 10500:1991 with its update IS 10500:2012. Hazardous effects of irrigation water [6] are classified into four major groups (1) Total Salt Concentration expressed as the EC in the scale of micro-mhos/cm, (2) SAR in the scale of Square root of millimole/L, (3) RSC in the scale of milliequivalent/L, (4) Percent Sodium. Water Quality Index (WQI) systems [7] are discussed. For setting water quality objectives of a water body, it is essential to identify the uses of water in that water body. In India, the Central Pollution Control Board (CPCB), an apex body in the field of water quality management, has developed a concept of "designated best use"and identified 5 classes (TABLE 4) [8]. According to which, out of several uses a particular water body, the use which demands highest quality of water is called its "designated best use", accordingly it is designated.

Table 2: Ir. HWQR

Ir. HWQR	Salt conc. as EC (micromhos/cm)	SAR (millimole/L)$^{1/2}$	RSC (me/L)	Percent Sodium (%Na)
Low	Below 1500	Below 10	Below 1.5	<20
Medium	1500-3000	10-18	1.5-3.0	20-40
High	3000-6000	18-26	3.0-6.0	40-60
Very high	Above 6000	Above 26	Above 6.0	60-80

Table 3: Limit as per BIS/ IS:11624 (1986), IS 10500:1991, IS 10500:2012

Sl No.	Parameter (except pH, expressed as mg/L)	Acceptable Limit	Permissible Limit in absence of alternate source
1	pH	6.5 – 8.5	6.5 - 8.5
2	TDS	500	2000
3	Calcium (as Ca)	75	200
4	Chloride (as Cl)	250	1000
5	Magnesium (as Mg)	30	100
6	Sulphate (as SO4)	200	400
7	Total Alkalinity (TA as CaCO3)	200	600
8	Total Hardness (TH as CaCO3)	200	600

Table 4: Primary Water Quality Criteria for Designated Best Uses by CPCB (PWQC)

	Parameters							
Designated-Best-Use	**Class of water**	**pH**	**DO mg/L**	**BOD mg/L**	**Free NH3 as N mg/L**	**EC micro mhos/cm**	**SAR**	**Total Coli form MPN /100ml**
Drinking water source without conventional treatment but after disinfection	A	6.5–8.5	≥ 6	≤ 2	-	-	-	≤ 50
Outdoor bathing (Organized)	B	6.5–8.5	≥ 5	≤ 3	-	-	-	≤ 500
Drinking water source after conventional treatment and Disinfection	C	6.0–9.0	≥ 4	≤ 3	-	-	-	≤ 5000
Propagation of Wild life and Fisheries	D	6.5–8.5	≥ 4	-	-	-	-	-
Irrigation, Industrial Cooling, Controlled Waste disposal	E	6.0–8.5	≥ 4	-	-	2250	26	-

IV. EXPERIMENTATION

The sampling points are sequenced from upstream to downstream and shown diagrammatically at Fig.4 with representation as S1–18 along the Yanamadurru drain and River Gosthani stretches grouped as S1–7 (Gr.1), S5 inlet pipe, S8, S10, S14–18 (Gr.2), S9, S11–13 (Gr.3).

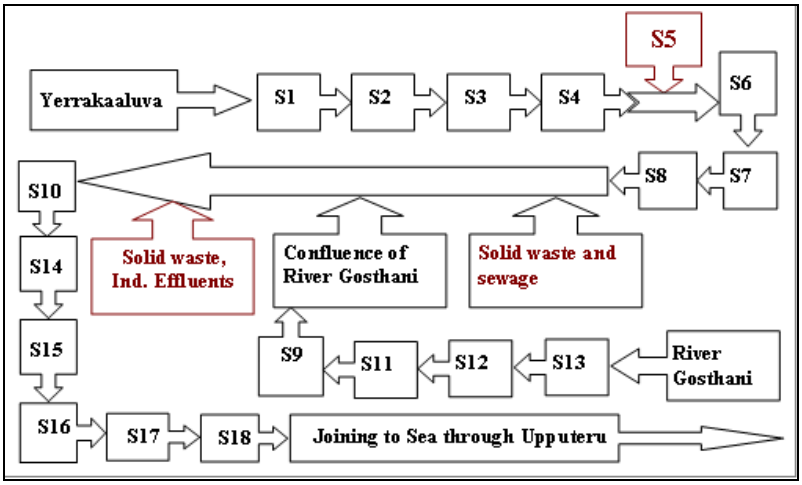
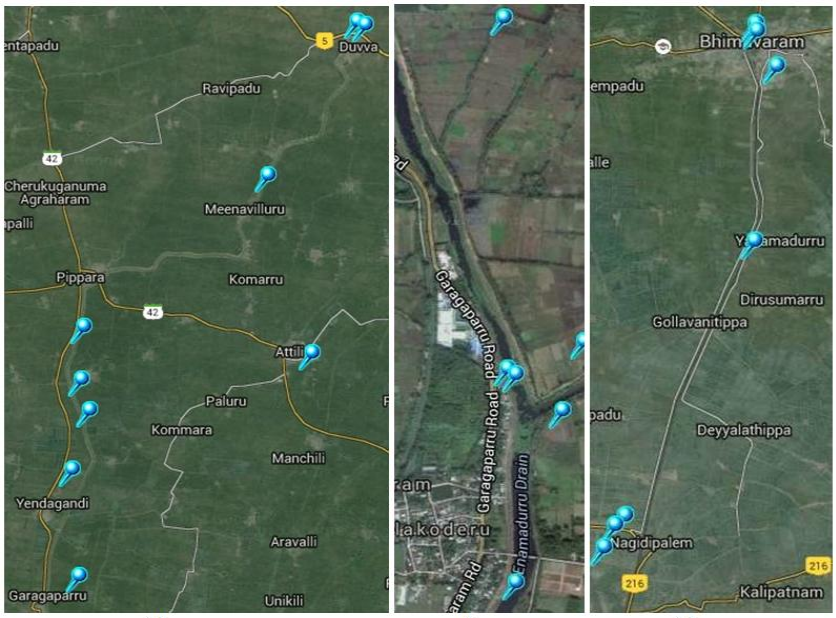


Figure 4: S1–7 (Gr.1), S5 inlet pope, S8, S10, S14–18 (Gr.2), S9, S11–13 (Gr.3).

Fig.5 shows the stretch marked with sampling points of Yanamadurru Drain in three blocks from upstream (a) Duvva – Garagaparru, (b) River Gosthani confluence, Garagaparru – Gollalakoderu and (c) Bhimavaram – Nagidipalem, before confluence to Upputeru around 5km apart from sea Bay of Bengal.

V. CHECKING CORRECTNESS OF ANALYSIS [9]

The following procedures are applied to water samples for which relatively complete analysis is made. These include pH, EC, TDS and major anionic and cationic constituents that are indications of general water quality. The data is classified as Primary, Secondary, Significant and Non-significant parameters.



(a) (b) (c)

Fig. 5: Stretch of Yanamadurru Drain marked with sampling points (a) Duvva – Garagaparru, (b) River Gosthani confluence, Garagaparru – Gollalakoderu and (c) Bhimavaram – Nagidipalem

Primary Analysis Data contains Station code, Monitoring date, organic and specific constituents (COD, BOD, DO, TSS, pH, EC), non-significant constituents (Fluoride, Boron, Ammonia, Nitrate, Nitrite, Phosphate) and significant constituents (TDS, Chloride, Sulphate, Sodium, Potassium, Total Hardness (T.H), Calcium Hardness (Ca.H), Total Alkalinity (T. Alk.) and Phenolphthalein Alkalinity (Phe. Alk.)). Secondary Data is derived from Significant data such as Calcium, Magnesium, Carbonate, Bicarbonate, percent sodium, SAR, etc. for checking Correctness of Analysis and material balance.

The short titles incorporated at TABLES 5-7 are Electric Conductivity (EC) micro mhos/cm; Total Dissolved Solids (TDS) mg/L; Sum of all cations i.e., significant cations and non- significant cations (ACS); Sum of all anions i.e., significant anions and non-significant anions (AAS); Sum of weights of all ions or Calculated TDS with all ions (ACTDS) mg/L; For all ions, Anion cation balance as %diff. (AACD); Sum of major cations or significant cations (MCS); Sum of major anions or significant anions (MAS); Sum of weights of significant cations and significant anions (MCTDS) mg/L; Significant cations and significant anion balance as %diff. (MACD).

TDS by calculation = 0.6 (Alkalinity) $+Na^{+} +K^{+} +Ca^{2+} +Mg^{2+} +Cl^{-} +SO_4^{2-} +SiO_3^{2-} +NO_3^{-} +F^{-} +PO_4^{3-}$

The anion and cation sums, when expressed as milliequivalents (meq.) per liter, must balance because all potable waters are electrically neutral i.e. around 7.0 pH. The test is based on the percentage difference {defined as %difference = ((Σ cations – Σ anions)/(Σ cations + Σ anions))}. The typical acceptance criteria based on 0-3.0, 3.0-10.0 and 10.0-800 ranges of anion sums lies $\pm$0.2, $\pm$0.2 and $\pm$0.5, respectively.

Measured EC and ion sum: Both the anions and cations should be 1/100 of the measured EC value. The acceptable criteria are 100 * anion (or cation) sum, *meq/L* = (0.9-1.1) EC. Calculated TDS to EC ratio acceptable criteria for the ratio of calculated TDS to EC is as follows: Calculated TDS / conductivity ≈ 0.55 – 0.7. Measured TDS to EC ratio acceptable criterion is ≈ 0.55 – 0.7.

5.1. Action to be taken in conducting Analysis

If the *%difference* is not in acceptable range, it indicates that some measurement of ions is missing to be identified and to be analyzed. It indicates reanalysis. The measured TDS should be higher than the calculated one because a significant contributor may not be included in the calculation. The acceptable range is Measured TDS / Calculated TDS $\leq$ 1.2 for potable waters.

If the measured value is less than the calculated one, the higher ion sum and measured value are suspect; the sample should be reanalyzed. If the measured solids concentration is more than 20% higher than the calculated one, the low ion sum is suspected and selected constituents should be reanalyzed. If measured EC and ion sum ratio does not meet the criterion, that sum is suspect; reanalyze the sample.

Calculated TDS to EC ratio ≈ 0.55 – 0.7, and falls below 0.55 or above 0.7, the lower ion sum or the higher ion sum is suspected; reanalyze it, respectively. If reanalysis causes no change in the lower ion sum, an unmeasured constituent, may be present at a significant concentration. If poorly dissociated Calcium and

Sulphate ions are present, the Calculated TDS may be as high as 0.8 times the EC.

Checking Correctness of Analysis methods mentioned above provide only tentative relations between the experimental parameters and the derived parameters.

VI. EXPERIMENTATION AND RESULTS

Analysis data is placed at TABLES 5 – 6. TABLE 5 represents the organic load and ions of minor constituents except heavy metals such as COD, BOD, DO, TSS, pH, EC, Fluoride, Boron, Nitrogen as Ammonia / Nitrate / Nitrite and Phosphate.

Table 5: pH and ions of major constituents of water

Station code	Monitoring date March 2016	COD (mg/L)	BOD (mg/L)	DO (mg/L)	TSS (mg/L)	pH	Conductivity (mS/cm)	Fluoride (mg/L)	Boron (mg/L)	AmmoniaN (mg/L)	NitrateN (mg/L)	NitriteN (mg/L)	Phosphate (mg/L)
S1	12	12	3.6	7.5	16	7.3	312	0	0	0.1	3	1	0.03
S2	12	8	3.1	7.4	14	7	529	0.32	0	0	4	0	0.28
S3	12	16	4.5	7.4	22	7.1	695	0.45	0	0.1	5	1	0.07
S4	12	20	5.7	7.2	12	6.9	759	0.6	0	0.1	4	2	0.26
S5	12	332	60	5.4	236	7.2	11540	0.25	0	0.7	9	13	0.35
S6	12	12	4.9	7.4	4	7.5	1695	0.46	0	0.1	5	2	0.3
S7	12	116	42	5.8	608	6.7	2720	0.46	0	0.8	10	3	2.8
S8	12	64	13.9	6.6	62	6.5	2710	0.13	0	0.9	23	1	1.5
S9	12	108	36	5.6	23	6.8	2270	0.14	0	0.4	23	3	0.12
S10	12	288	88	4.8	2346	6.5	2780	0	0	2.2	26	2	4.5
S11	12	88	20.5	6.2	92	6.6	3880	0	0	0.3	26	2	0.25
S12	12	36	11.7	6.4	43	7.1	3990	0.15	0	0.6	11	27	0.16
S13	12	36	11	6.4	42	7	2310	0.73	0	1.2	10	3	0.26
S14	13	34	11	6.2	106	6.7	2840	0.02	0	1.5	23	1	1.9
S15	13	100	32	5.4	80	6.7	2820	0	0	1.4	29	1	2.2
S16	13	88	28	5.8	26	6.8	2650	0.19	0	1.3	24	1	2.1
S17	13	72	22	6	172	6.9	3030	0.02	0	2.1	20	1	1.95
S18	13	340	89	4.2	142	7.6	26500	0.49	0	5.7	9	1	1.9

TABLE 6 shows TDS, Chlorides, Sulphates, Sodium, Potassium, Total Hardness, Total Alkalinity, and secondary data such as Calcium, Magnesium, Bicarbonates, percent Sodium and SAR, representing ions of major constituents of water.

Table 6: Organic load and ions of minor constituents except heavy metals

Station code	TDS (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	Sodium (mg/L)	Potassium (mg/L)	T.H (mg/L)	Ca.H (mg/L)	Total Alk. (mg/L)	Ca++ (meq.)	Mg++ (meq.)	HCO3- (meq.)	%Na	SAR
S1	210	30	6.2	32.3	2.6	80	60	140	24.0	4.9	140.0	46.8	1.6
S2	360	40	5.05	51.2	1.8	160	110	260	44.1	12.2	260.0	41.0	1.8
S3	520	50	21.7	85.6	3.3	170	90	300	36.1	19.4	300.0	52.3	2.9
S4	560	90	20.7	104.6	4.0	210	100	320	40.1	26.7	320.0	52.0	3.1
S5	8078	3324	922	1757.8	38.7	2260	639	280	256.1	393.9	280.0	62.9	16.1
S6	1240	410	140	202.9	78.1	440	170	250	68.1	65.6	250.0	50.1	4.2
S7	2120	610	176	380.9	22.8	550	230	380	92.2	77.8	380.0	60.1	7.1
S8	2060	590	82	324.9	22.9	610	309	430	123.8	73.1	430.0	53.7	5.7
S9	1680	470	104	275.5	24.6	600	289	440	115.8	75.6	440.0	50.0	4.9
S10	2100	620	74	362.9	24.8	650	350	540	140.3	72.9	540.0	54.8	6.2
S11	2910	790	502	569.7	20.3	780	339	320	135.9	107.2	320.0	61.4	8.9
S12	2990	820	739	526.5	23.5	790	330	280	132.3	111.8	280.0	59.2	8.1
S13	1710	530	126	295.1	20.6	530	280	330	112.2	60.8	330.0	54.8	5.6
S14	2200	660	65.1	373.8	25.3	690	259	480	103.8	104.7	480.0	54.1	6.2
S15	2060	660	59.5	373.8	21.3	630	284	490	113.8	84.1	490.0	56.3	6.5

S16	2020	570	48.2	307.8	21.9	630	330	480	132.3	72.9	480.0	51.5	5.3
S17	2300	700	64.3	421.6	29.3	670	299	500	119.8	90.2	500.0	57.8	7.1
S18	20670	9222	1006	7640.6	48.7	3140	469	400	188.0	649.1	400.0	84.1	59.3

TABLE 7 represents the ions of heavy metals indicating minor constituents. Most of results are with in the scope of validation with little deviations in some parameters such as TSS and Sulphates; especially sample S6 that is indicating low TDS and EC may be result of sampling, field conditions and analysis part.

Table 7: Ions of heavy metals indicating minor constituents

Station code #	Lead (Pb)	Iron (Fe)	Zinc (Zn)	Nickel (Ni)	Copper (Cu)	Chromium (Cr)	Cadmium (Cd)
S1	ND	ND	0.062	ND	0.015	ND	0.003
S2	ND	ND	0.139	ND	0.002	ND	ND
S3	ND	ND	0.029	ND	ND	ND	ND
S4	ND	ND	0.035	ND	ND	ND	ND
S5	0.035	0.019	0.04	ND	0.003	ND	0.01
S6	ND	ND	0.074	ND	ND	ND	ND
S7	ND	0.037	0.021	ND	ND	ND	ND
S8	ND	0.118	0.039	ND	ND	ND	ND
S9	ND	0.046	0.034	ND	ND	ND	ND
S10	ND	0.153	0.014	ND	ND	ND	ND
S11	ND	0.107	0.254	ND	ND	ND	ND
S12	ND	ND	0.386	ND	ND	ND	ND
S13	ND	ND	0.023	ND	ND	ND	ND
S14	ND	0.061	0.043	ND	ND	ND	ND
S15	ND	0.076	0.026	ND	ND	ND	ND
S16	ND	0.005	0.024	ND	ND	ND	ND
S17	ND	0.017	0.652	ND	ND	ND	ND
S18	0.052	0.03	0.162	ND	ND	ND	0.021

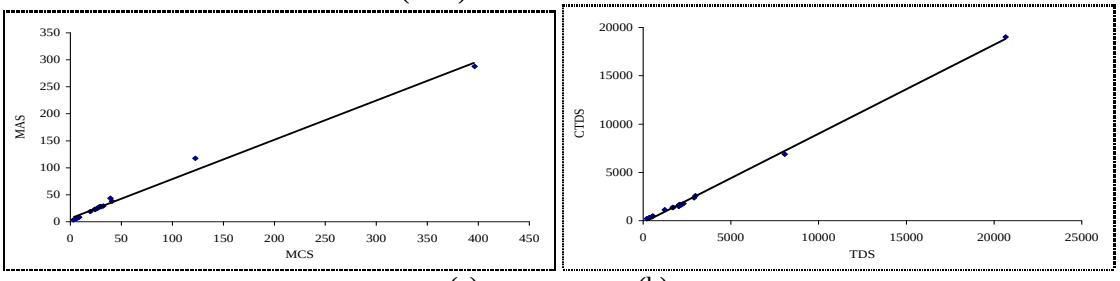
ND refers the value at below detectable range and to be treated as Zero for all practical purposes.

VII. DATA ANALYSIS, DISCUSSIONS AND CONCLUSIONS

There is a web of branch canals originated from Dowaleswaram anicut on River Godavari and Yerrakaluna Reservoir surround Yanamadurru drain facilitating drainage system and hence it has many inlets with control to prevent back flow. The monitoring is started in the afternoon section of a sunny day and due to high chlorophylls activity the DO concentrations at all monitoring points showing greater than 4.8 mg/L irrespective of BOD and COD concentrations.

Fig. 6 is showing the redundancy of analysis data with respect to (a) Sum of Cations verses Sum of Anions (MCS vs. MAS), (b) Total Dissolved Solids verses Calculated TDS (TDS vs. CTDS) indicating the accuracy of analysis.

Samples are grouped S1-7 with separate entity for S5 are as Veyyur Canal stretch (Gr.1). Samples S8, S10, S14-18 are as Yanamadurru before confluence with River Gosthani, Garagaparru to Upputeru stretch (Gr.2) and S9, S11–13 are as River Gosthani stretch (Gr.3).



(a) (b)

Fig. 6: Data redundancy in respect to (a) MCS vs. MAS, (b) TDS vs. CTDS

7.1. Gr.1 sampling points

Gr.1 sampling points, S1-7 are in the order from the Yanamadurru Drain starting points to Garagaparru (V) except S5 that is discharged through pipe line into drain near Kesavaram (V) from fish/prawn hatcheries between S4 and S6. Hence, S5 is referred separately. The range and average of pH for Gr.1 are 6.7-7.5 and 7.1, respectively, representing S1 (7.3) >S2 (7.0) <S3 (7.1) >S4 (6.9) <S6 (7.5) >S7 (6.7 pH). From S1-7, decrease of pH found with up and downs along the stretch at Gr.1 points indicates increase of acetic nature. Gradual increase of EC and TDS from acceptable criteria (<500 mg/L) crossing the permissible limit in the absence of

alternate source (>2000). The trend of TDS is S1 (210) < S2 (360) < S3 (520) < S4 (560) < S6 (1240) < S7 (2120 mg/L) and S5 (8078) joins between S4–6 to the drain. The trends of EC is S1 (312) < S2 (529) < S3 (695) < S4 (759) < S6 (1695) < S7 (1220 mg/L) and S5 (11540). The BOD and COD fluctuate ranging from 3.1 – 42.0 and 8 – 116 mg/L, respectively, with small deviations support decrease in drain quality while moving downstream. DO is ranging 5.4 – 7.5 mg/L indicate the aeration capability of the drain to support aerobic aquatic life. Chloride, Sodium, Potassium, Total Hardness and Total Alkalinity trends are showing gradual increase of Gr.1 points. TSS values are supporting the same trends except at S6.

7.2 Gr.2 sampling points

Gr.2 sampling points S8, S10, S14-18 from Yanamadurru B/C of River Gosthani, Garagaparru – Upputeru confluence stretch. Yanamadurru drain, just before and after confluence of River Gosthani is 6.5pH while River Gosthani B/C is 6.8pH. River Gosthani water after confluence reached in Yanamadurru drain upstream point S8 also and used for irrigation agricultural fields.

TDS trends: S8(2060)<S10(2100)<S14(2200)>S15(2060)>S16(2020)<S17(2300)<<<<S18 (20670)

The trends of EC, TH, TA, Chlorides and Sulphate followed the above sequence.

COD and BOD trends with reference to TABLE 5: S8<<S10>>S14>>S15<S16<S17>>>S18

7.3. Gr.3 sampling points

Gr.3 sampling points, S9, S11–13 indicate the stretch of River Gosthani B/C with Yanamadurru drain. S9 indicate B/C with Yanamadurru drain and also after confluence of M/s. Deltapaper Mills (P) Ltd showing less TDS (in the acceptable range of discharge standards) than other points in the River Gosthani Stretch. The upstream points S11 and S12 indicate discharges from aquaculture fields and at upstream side S13 the TDS is in the acceptable range of discharge standards. The discharges from M/s. Deltapaper Mills (P) Ltd are around 11MLD and the flow from upstream is supposed to be 5MLD with 2910mg/L TDS in the River Gosthani indicate dilution of TDS before its confluence with Yanamadurru Drain. Hence, the farmers surrounding the confluence are draining River water before confluence for agricultural irrigation purpose. Opposite to B/C of Yanamadurru with River Gosthani, in upstream side, there is MSW and other Solid water dump on the bank and there are prawns and waste processing industries. Value of pH before and after confluence is 6.5 and it is 6.8pH at River Gosthani indicating putrefication / acidic waste discharges to Yanamadurru drain nearer to the River Gosthani confluence. Further, Sodium, TH, CaH, Chloride and Sodium increased, and abnormal increase of COD and TSS, after confluence of River Gosthani in Yanamadurru drain indicating there is some effluent discharges into drain which are to be identified and regulated. Bhimavaram town MSW dump to the Yanamadurru drain found at large quantities after Garagaparru streatch. The waters of Yanamadurru drain are changing from class A to D when reaching Garagaparru Village and irrigation hazard quality rating is "Medium".

7.4. Action Taken

A preliminary report is communicated to executive officers for taking measures to identify polluting inlet channels and implementing remedial measures in co-operation with other departments.

VIII. REMEDIAL MEASURES

The solid waste dump opposite bund of Yanamadurru near confluence of River Gosthani at Garagaparru is to be cleared and checked for wastewater inlets. Aquaculture on uplands from Bhimavaram Town and the fields drain lines joining to Yanamadurru drain and River Gosthani are to be restricted. The aquaculture on uplands spoils the ground water and agriculture field and hence penalization is to be imposed on defaulters. Bhimavaram town MSW dump into Yanamadurru drain and the existing MSW dump within Yanamadurru drain which is to be removed and restriction is to be imposed on solid waste dump to the drain in its bunds along the stretch.

The complainant's proposal of parallel pipe line for industrial and aquaculture discharges, which supports tremendous industrial growth and indiscriminate discharges without proper treatment spoils the coastline. If it is for aquaculture waste disposal, it is not supported due to spoil of agriculture land and ground water permanently. The industries are to be restricted to adopt proper treatment facilities for treating their effluents as per CPCB discharge standards. The treatment facilities and efficiency [10] show that proper maintenance and operation would serve for treating pollution of incoming water to acceptable safe levels.

Some of villager's report is that at high tide times, the sea waters (brackish water) through Upputeru reaches up to Kesavaram (V) in the Yanamadurru drain which attracts further study on the influence of sea water and self purification capabilities of the drain. It is suggested to track the pollution levels of the stretches of Yanamadurru drain and implement remedial measure River Gosthani may be monitored at regular intervals by the regulating agencies.

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