CONTAMINATION OF IRRIGATION CANALS AND ITS IMPACT ON HUMAN BEINGS AND LIVE STOCK

Jagapathi Raju Mantena[1], A.R.K. Raju Penmetsa[1], Vanisree Vallabhaneni[2], Raghu Ram Popuri[3], Rambabu Tenneti[3], Niharika Kondepudi[4]

[1] Professor, [2]Professor Emeritus, [3] Assistant Professor, [4]JRF

Water and Environment Technology (WET) Research Centre, Dept. of Civil Engineering, S.R.K.R. Engineering College, China Amiram, Bhimavaram, W.G.Dist. A.P., INDIA – 534204

vanisree.vallabhaneni@gmail.com

Abstract:

Water pollution has emerged as an important issue in India as most of the rivers are polluted, which are having substantial negative impact on human health and aquatic life. Heavy metals are potentially toxic to crop plants, animals and human beings. 90%of infectious diseases in developing countries are transmitted through polluted water. Western Delta of West Godavari is based on canal water for drinking, domestic and irrigation purposes. This is the source of drinking water for livestock also. Being deltaic area, soil is fertile and due to availability of plenty of water, intensive agriculture, intensive aquaculture, Poultry farms are functioning throughout the year. In Western Delta of West Godavari, there are six irrigation canals- Venkayya-Vayyeru, Eluru canal, Narsapur canal, Gostani-Velpuru canal, Kakaraparru and Right Bank canal and Attili canal. Water samples were collected from all these canals for two seasons and analyzed for physico- chemical and biological parameters like pH, TDS, EC, TH, TA, Turbidity,NH_3, NO_2, NO_3,Na,K , Cl ,DO,BOD, COD, TBC and E.Coli to understand the present status of the contamination of these canal waters. The assessed data also used to compare the concentration variation contaminants in winter and rainy seasons. Deltaic water is highly contaminated and not suitable for its consumption by humans and livestock.

Key words: Live stock, Contamination, Heavy metals, Pesticides, Bioaccumulation, Water pollution

1. Introduction:

Water is one of the most important of all natural resources on earth. Fresh water is vital for all life. It is a renewable, but finite natural resource. It is important to all living organisms, most ecological systems, human health and economic development. Demand for fresh water for households, agriculture and industrial use is increasing. The safety of drinking water is an ongoing concern within the global village[1,2].

Like many other countries in the world, in India too, the environmental pollution has become a cause of concern at various levels. The quality of water in the canals has deteriorated drastically over the years due to various reasons. The canal waters are highly polluted due to letting of sewage/sullage effluents from fish/prawn tanks, agricultural runoff carrying toxic chemicals, dumping of garbage and dead animals and human defecation along the canal banks. Due to lack

of sewage treatment plants, in most of the developing countries including India, untreated sewage effluents are released either on agricultural land for irrigation or disposed into nearby water bodies[3]. At present approximately 20% of the world's population lacks safe drinking water, and nearly half the world population lacks adequate sanitation. This problem is acute in many developing countries, which discharge an estimated 95% of their untreated urban sewage directly into surface waters. In India only 8 out of total 3119 towns and cities have full waste water treatment facilities. Downstream, the untreated water is used for drinking, bathing and washing, resulting in serious human infections and illness[4].

Many of the agricultural chemicals including nitrogen fertilizer contaminate aquatic eco-systems through leaching and run-off, resulting in the eutrophication of aquatic ecosystems and other environmental problems. Worldwide pesticides alone contribute to an estimated 26 million human poisoning and 2, 22,000 deaths each year.

Heavy metals contribute to environmental pollution because of their unique properties, mainly that they are non-biodegradable, non-thermo degradable and generally do not leach from the top soil. Heavy metals can accumulate to toxic concentrations that affect plant and animal life. The duration of contamination by heavy metals may be for hundreds or thousands of years, even after their addition to soils had been stopped[5,6].

One of the threats to food quality and safety in these areas are heavy metals in industrial effluents and from sewage plants. Dietary intake of heavy metals is a substantial risk to the health of families who depend upon the use of contaminated irrigation water to irrigate their crops and to meet their food requirements. Plants frequently act as bio accumulators of heavy metals, with concentrations in crops such as spinach, cauliflower and wheat reported to exceed international food standards in several earlier studies made across the country. The extent of contamination is likely to increase with intensification of production systems, urbanization and industrialization. Continuous application of sewage effluents to arable lands will go on increases the concentration of these heavy metals in the feeding zone of plant roots, which may not only become toxic to plants but would also create critical problems in animals and human beings because of entry of micronutrients and heavy metals into the food chain. The sewage irrigated soils have the potential to act as storehouses of micronutrients, heavy metals, toxicants, biologically dangerous microorganisms, pathogens and parasites[8].

It has been found that pollution has been given rise to four major problems.viz.1.Pollution of drinking water. 2. Pollution of irrigation water. 3. Large incidence of diseases like arthritis, diarrhea, gastro enteritis, skin allergies, stomach pain, malaria, food poisoning, eye diseases, jaundice and pediatric problems. 4. Impact on livestock and cropping pattern.

West Godavari Western delta is extremely fertile getting water abundantly throughout the Cotton barrage built on the Godavari River. Topographically the district is divided into the delta and upland. In the delta, aquaculture, coconut, lemon and rice mainly are cultivated. The district is popularly known as the granary of India since 50% of the state's rice production comes from this district. In the coastal belt of the district, prawn and fish are cultivated and exported to Japan, France and USA. Like all rivers across India, Godavari also faces severe pollution from urban and rural sewages, agricultural run-off and industrial effluents. Godavari delta is one of the most fertile and is a densely populated zone of intense economic activity. Infested with wastes ranging from floating plastic bags to chemicals, our water bodies have turned into a pool of poison. The most basic effect of water pollution is directly suffered by the organisms and vegetation that survive in water. Several people and cattle die each day due to consumption of polluted and infected water.

Water pollution may disrupt photosynthesis in aquatic plants and thus affecting ecosystem that depend on these plants. Terrestrial and aquatic plants may absorb pollutants from water (as their main nutrient source) and pass them up through food chains to consumer animals and humans. Soil pollution caused by water pollution may alter plant metabolism and reduce crop yields. Yanamadurru stream, once a good drinking water source for cattle and other livestock now became a cess-pool and spreading foul smell, spoiling the health all living beings. Kolleru Lake a renowned fresh water lake is also polluted due to untreated rural, urban and industrial sewage waters. This contamination also leads to the loss of bio-diversity and extinction of the species.

Pesticides are specifically applied to the environment with the aim to suppress plant and animal pests and to protect agricultural and industrial products. However, the majorities of pesticides are not specifically targeting the pest only but also affect non-target plants and animals. Many pesticides are not biodegradable and persist in soil, leach ground water and surface water and contaminate wide environment. Depending on their chemical properties they can enter the organism, bio-accumulate in food chain and consequently influence human health and live stock. The most commonly used pesticides are herbicides and insecticides like Atrazine, Simazine, Alachlor, Metolachlor, Triflurain, Diazinon, Parathion and Organochlorine compounds like Lindane, Endosulfan, Aldrin etc.

Nevertheless, heavy metals in the environment, consequently, one of immense concern, because of their persistant nature, bioaccumulation and bio magnification characters causing eco toxicity to plants, animals and human beings.

Livestock need clean non-contaminated drinking water. Live stock can use water in irrigation canals. Contamination of irrigation and drainage water with residues from agrochemicals can form a health risk for livestock and people consuming animal products from these animals. Performance problems associated with poor water quality and reduced feed intake may include reduced growth and weight, lower reproductive potential and reduced lactation. High levels of specific ions in water can cause animal health problems and death. Excess fluoride causes

degeneration of the teeth. Excess sulphates cause scours. Salts such as sodium chloride change the electrolyte balance and intercellular osmotic pressure etc., leads to dehydration in the body and also creates stress on kidneys.

Heavy metals are potentially toxic to crop plants, animals and human beings. Human health is directly affected through intake of crops grown in polluted soils. There is a clear evidence that human renal dysfunction is related with contamination of rice with cadmium in subsistence farms in Asia. Indeed, in Asia, rice has been identified as one of the major source of cadmium and lead for human beings.

The study of water pollution on soil microorganisms should be deeply investigated because some pollutants may not directly suppress the growth of a crop but may stimulate the growth of microorganisms. If this is the case, the nutrition imbalance and the formation of dominant microorganisms may indirectly influence the growth of plants. Patrick et al (1971) pointed out that plants may easily be susceptible to soil pathogens when the plant has been previously retarded by soil phytotoxins.

The young seedlings of rice and other crops are easily harmed by pollutants. The control of polluted water running into farmland is of fundamental importance, otherwise, agricultural land will be greatly jeopardized and may never return to its original status if we do not prevent polluted water from running into the fields.

The microbial quality of drinking water can also be important. Illnesses caused by drinking contaminated water leads to number of waterborne diseases. Common issues associated with canal water and cattle include blooms formed by blue green algae or cyano- bacteria. Most blooms of blue green algae contain either brain toxins (Neuro toxins) or liver toxins (Hepato toxins).Algal blooms can create a bad taste and odor. Just over a liter of water can be fatal to 100kg calf, depending on the toxins present in the blue green algal bloom. Another disease that affects mature cattle is Leptospirosis which can cause abortion problem. The disease can spread rapidly through a herd as a result of manure entering into surface water from infected animals.

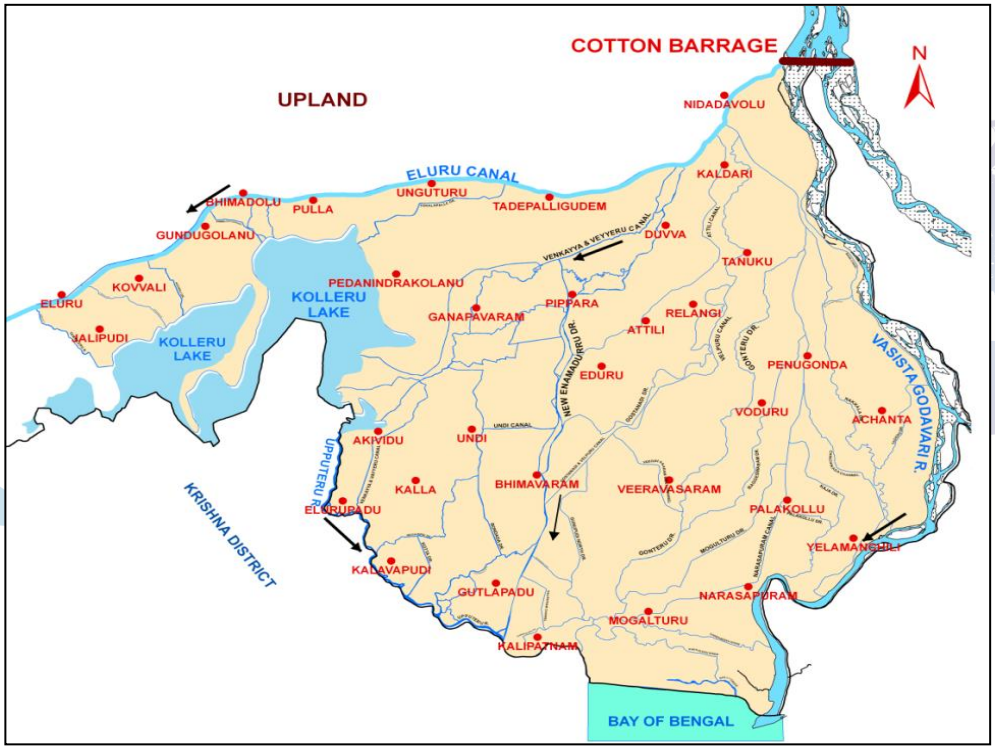
The incidence of Schistosomiasis, which is also associated with contaminated fresh water, is expanding worldwide. Each year this disease caused by a parasitic worm contacted by more than 200 million people and causes an estimated 20,000 deaths. Mosquito-borne malaria is also associated with water bodies. World-wide, this disease infects more than2.4 billion people and kills about 2.7 million each year. Another serious infected disease associated with poor water quality is tuberculosis, which can be transmitted through air, water and food. At present, approximately two billion people are infected with tuberculosis and the number is increasing each year. In addition, about two billion people worldwide are infected with one or more types of helminthes like tapeworm, liver fluke, leech etc. either through direct penetration of their skin or through the use of contaminated water or food.

Contamination of canal water also takes place by livestock. Contaminants are commonly found in feces and urine of animals can be bacteria such as *Salmonella*, *Campylobacter* or *E.coli*; Viruses or parasites such as Giardia, Cryptosporadia and infrequently Toxoplasma. Water borne diseases are usually caused by the contamination of drinking water with feces from infected domestic animals like cows, horses, dogs etc and wild animals like bears, deer, rodents, birds and humans or a combination of these.

Health problems are multiplied for agricultural workers due to pathogenic bacteria, viruses and parasites present in the drain water. Hookworm infections are more in agricultural workers who go barefoot in waste water irrigated fields.

2. Study Area:

Fig No:1 Study area



The Study Area lies between 16°19’05.02”and 16°56’08.37”N latitudes and 80°58’16.10” and 81°51’26.10” E longitudes and situated in the Southern part of West Godavari District. It is bounded in the East by Godavari River, North by Eluru canal and West by Upputeru River and Kolleru Lake. The major canals in the area are Venkayya-Vayyeru canal, Attili canal, Eluru canal, Kakaraparru and Bank canal, Gostani canal and Narsapur canal. Geologically, the Western Delta Region is underlain by coarse sand with black clay of Buried Channel (BC) zone, black silt clay of Flood Plain (FP) zone and grey/white fine sand of beach sediment of coastal zone.

3. Materials and Methods:

West Godavari is one of the 13 districts of Andhra Pradesh. West Godavari occupies an area approximately 7700square kilometers. Canal water samples were collected from all the six canals for two seasons' viz. winter and rainy seasons. In summer season canals were closed so there is no scope for sample collection. Water samples collected from various canals were analyzed for pH, TDS, EC, TH, TA, Turbidity, Na K, Cl, NH_3, NO_2, NO_3, DO, BOD and COD. For a few samples Total Bacterial Count (TBC) and E.Coli were also measured[13].

4. Results and Discussion

As Canal is a running water body, oxygen can be replenished and some of the contaminants may be oxidized. In winter season during October, November, December and January months of 2014 and 2015 about 101 samples were collected from all the six canals of study area and analyzed. It was observed that the pH values of the samples are within the standard drinking water limits (BIS 10500) of 6.5 to 8.5 in majority of the samples except Ganapavaram, Bayayyapalem, Pedakapavaram and China Kapavaram of Venkayya-Vayyeru; Mandapaka of Attili canal; Nandamuru, Navabpalem, Krishnayyapalem, T.P. Gudem, Pentapadu, Chebrolu and kaikaram of Eluru canal; Irragavaram and Tanuku in Gostani canal; Aitampudi, Penugonda and Neggipudi in Narsapur canal. The TDS values are also within the permissible limits of 150-500ppm except in Juvvalapalem area. In Venkayya Vayyeru canal area, high TDS values are obtained in the villages of Prathellameraka , Kalavapudi and Elurupadu due to the influence of Upputeru backwater. EC values are also same as to TDS values and Chloride values are also crossed the permissible limit of 250ppm in these villages. Hardness and Alkalinity values of all the canal water samples are within the optimum limits of 300ppm and 250 ppm respectively. Nitrate values are also below the permissible limits of 45ppm in all the samples. Dissolved Oxygen is an important parameter for assessment of suitability of water quality because it is essential to sustain different variety of biological life in the water system. Waste discharge effects on water system are determined by the oxygen balance in the aquatic body. DO is a regulator of metabolic activities of living organisms and governs metabolism of the biological communities as a whole and also acts as an indicator of the trophic status of the water body. Oxygen is generally reduced in the water due to respiration of biota, decomposition of organic matter, rise in temperature, oxygen demanding wastes and inorganic reductants such as hydrogen sulphide, ammonia, nitrites, ferrous iron etc. Minimum of 3mg/l dissolved oxygen is necessary for healthy fish and other aquatic life.

BOD and COD values are high in Kakaraparru/Bank canal area particularly in the villages Settipeta, Velivennu, Tadiparru, Sitaramapuram , Mutyalapalem, Rameswaram and Bhimulapuram; and in Venkayya-Vayyeru canal particularly kalavapudi, Ganapavaram and Bavayyapalem. Microbiological contamination of Venkayya-Vayyeru canal is more.(Because drain water is directly mixed with canal water).

Chloride concentration in water indicates the presence of organic waste in water, primarily of animal origin. It increases with ammonical nitrogen which is mostly due to contamination of human and animal excretory wastes. According to Indian standards IS-2296: 1974 the chloride concentration for irrigation purpose should be 600mg/l.

Table No.1:Average values of Physico-chemical parameters of various canal waters with seasonal variations

	Name of the canal	Venkayya Vayyeru canal		Eluru canal		Kakaraparru canal		Gostani canal		Attili canal		Narsapur canal	
S.No	Parameter	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy
1.	pH	8.30	8.24	8.60	8.10	8.38	8.31	8.18	8.23	8.17	9.00	8.40	8.46
2.	TDS	298	327	154	174	124	155	171	173	126	159	137	171
3.	EC	422	466	227	245	178	217	248	252	186	225	199	246
4.	TH	100	130	85	110	91	85	100	108	76	119	85	104
5.	TA	116	130	105	92	84	131	107	84	90	60	86	72
6.	Turb.	6.8	6.9	3.0	11	2.8	7.9	6.1	5.6	4.3	4.6	0.73	4.72
7.	NH_3	0.46	0.01	0.019	0.05	0.02	0.01	0.07	0.08	0.00	0.004	0.03	0.00
8.	NO_2	0.09	0.03	0.018	0.01	0.01	0.007	0.03	0.35	0.02	0.002	0.14	0.01
9.	NO_3	9.4	7.73	9.8	12.1	13.0	9.54	5.77	4.99	4.4	6.15	13.2	3.04
10.	Na	53.1	69.0	31	49	27	42	38	36.6	45	33.9	31	23.33
11.	K	2.60	2.30	2.50	1.20	1.70	1.0	2.5	2.7	0.6	3.2	2	8.03
12.	Cl	120	98.51	30.25	35.00	100	31.9	40.26	39.3	23.5	75	35.7	118.3

In second phase i.e.in rainy season, during the months of July, Aug., Sep., and Oct.2016 water samples were collected and analyzed for the same parameters of winter season. In Venkayya Vayyeru canal, Chinakapavaram, Modi villages the TDS values crossed 500 ppm and in Kalla,Pallepalem,Kalavapudi villages TDS values crossed 400ppm. Correspondingly sodium values are also more in Chinakapavaram and Modi followed by Kalla and Pallepalem which crossed 100ppm. Chloride values are also very high in Chinakapavaram and Modi crossed 250ppm followed by Kalla, Pallepalem, Kalavapudi, Prathella meraka, Juvvalapalem, Elurupadu, Cherukumalli, Ayi-Bhimavaram, Ajjamuru and Akividu crossed 100ppm.

Table no:2 DO, BOD, COD values of Venkayya-Vayyeru canal

S.NO	Village name	DO (ppm)	BOD (ppm)	COD (ppm)
1.	Akividu	4.4	3.6	19.2
2.	Muddapuram	7.4	3.6	9.6
3.	Ravipadu	6.4	3.6	19.2
4.	Chintapalli	6.6	3.3	48.0
5.	Jallikommara	6.6	3.6	22.4
6.	Bhuvanapalli	6.2	2.4	41.6
7.	Pedakapavaram	6.8	3.6	16.2
8.	Chinakapavaram	7.8	1.4	3.2
9.	Gummuluru	7.4	2.4	5.6
10.	Undi	5.8	4.2	9.0
11.	Kalisipudi	5.2	4.6	11.5
12.	Cherukuvada	5.4	2.4	8.2
13.	Ajjamuru	4.6	3.5	9.6
14.	Ayi-Bhimavaram	4.8	3.6	20.2

15.	Cherukumalli	3.8	2.4	10.5
16.	Juvvalapalem	4.2	2.4	12.6
17.	Elurupadu	4.8	3.6	15.0
18.	Prathella meraka	5.8	3.6	9.6
19.	Kalavapudi	5.6	6.0	19.2
20.	Ganapavaram	5.0	6.0	9.0
21.	Bhavayyapalem	5.6	6.0	19.2
22.	Kalla	5.5	2.7	8.5
23.	Pippara	5.8	2.5	6.8
	Averages	5.7	3.4	15.5

Table No:3 DO, BOD, COD values of Kakaraparru and Bank canal

S.NO	Village	DO	BOD	COD
1.	Settipeta	7.2	12.0	28.8
2.	Velivennu	7.4	10.8	19.2
3.	Tadiparru	7.4	10.8	19.2
4.	Sitaramapuram	7.2	13.2	28.4
5.	Mutyalavaripalem	6.8	12.0	32.0
6.	Malleswaram	7.4	15.6	51.2
7.	Siddhantam	6.8	3.6	9.6
8.	Nadipudi	7.2	4.8	16.0
9.	Uttarapalem	7.4	4.8	19.2
10.	Koderu	7.4	6.0	19.8
11.	Bhimulapuram	7.0	7.2	16.0
12.	Burugupalli	6.8	3.6	19.2
13.	Doddipatla	6.8	2.4	8.8
14.	Nakkapalem	7.2	4.8	16.0
	Averages	7.1	7.9	22.4

Table No:4 DO,BOD and COD values of Attili Canal

S.NO	Village	DO	BOD	COD
1.	Khaldari	6.2	2.4	8.0
2.	Vadluru	5.0	4.8	19.2
3.	Tetali	5.2	3.6	25.6
4.	Pydiparru	6.2	3.6	25.6
5.	Mandapaka	7.2	2.4	6.0
6.	Manchili	5.8	4.89	22.4

Table No:5 TBC and E.Coli at a few points of Venkayya-Vayyeru canal

S.NO	Village	TBC	E.Coli
1.	Muddapuram	$40x10^5$	$11x10^3$
2.	Ravipadu	$110x10^5$	$90x10^3$
3.	Chintapalli	$95x10^5$	$81x10^3$
4.	Jallikommara	$186x10^4$	$6x10^2$
5.	Bhuvanapalli	$214x10^4$	$89x10^2$
6.	Pedakapavaram	$234x10^4$	$142x10^2$
7.	Chinakapavaram	$57x10^4$	$13x10^2$
8.	Gummuluru	$146x10^4$	$72x10^2$
9.	Ganapavaram	$30x10^4$	$40x10^2$
10.	Bhavayyapalem	$146x10^4$	$72x10^2$

Table No:6 TBC and E.Coli at a few points of Attili Canal

S.No	Village	TBC	E.Coli
1.	Vadluru	$132x10^4$	0
2.	Tetali	$162x10^4$	0
3.	Pydiparru	$66x10^4$	0

E.Coli is zero

Table No: 7 TBC and E.Coli at a few points of Kakaraparru and Bank canal

S.No	Village	TBC	E.Coli
1.	Settipeta	$15x10^2$	$4x10^2$
2.	Veluvennu	$30x10^4$	$7x10^2$
3.	Tadiparru	$28x10^4$	$10x10^2$
4.	Sitaramapuram	$28x10^4$	$1x10^2$
5.	Mutyalavaripalem	$75x10^4$	$25x10^2$
6.	Malleswaram	$20x10^4$	$1x10^2$
7.	Siddhantam	$50x10^4$	$13x10^2$
8.	Nadipudi	$25x10^4$	0
9.	Uttarapalem	$30x10^4$	$10x10^2$

5. Conclusion:

In deltaic area microbial contamination is more than chemical contamination. However due to over usage of pesticides and fertilizers, chemicals particularly heavy metal concentrations are increasing in canal waters. During summer, the canals are closed and the stagnant water concentrated with all types of contaminants is the only drinking water source for birds and other livestock. In summer months, due to water scarcity the quality of canal water is highly

deteriorated and causes various types of diseases. The multifold development of Cyano bacteria, fecal coli form, fungi and virus causes health problems not only for human beings but also for live stock. In summer months particularly, the scarcity of water, poor maintenance of summer storage tanks and untreated or partially treated water is consumed by most of the rural people and affected by various diseases.

6. Recommendations:

1. At the village level itself, it is necessary to identify the sources of pollution and provide remedial measures
2. It is necessary to give top priority for the provision of safe drinking water and improve medical facilities for the affected people.
3. Measures have to initiate at macro and micro level to improve the soil conditions
4. In order to reduce pollution levels in irrigation canals, various initiatives like treating and diverting liquid wastes into drainage canals, converting solid wastes into compost/ organic manure, avoiding the dumping of dead animals, birds, fishes etc.
5. Village water tanks should not be allowed for aquaculture and at least one tank with full water (365 days) must be reserved for cattle and other livestock in each village.
6. Awareness programmes must be conducted to educate the public regarding the maintenance of quality and quantity of canal waters.

7. Acknowledgements:

This is a part of the work under the project No.DST/TM/WTI/2K14/183 (G) sponsored by Technology Mission Cell: Water and Solar Energy, Department of Science and Technology, New Delhi. The authors express their sincere gratitude to Dr. D. R. Prasada Raju, former Scientist-G/Adviser& Head (TMC), Dr. Sanjay Bajpai, Associate Head, Scientist F and Dr.Neelima Alam, Scientist-D, Technology Mission Cell: Water and Clean Energy, Department of Science and Technology, Govt. of India, New Delhi for their encouragement and guidance. We are also acknowledging the Principal and Management of S.R.K.R. Engineering College, Bhimavaram for their support in our research work.

8. References:

1. Pollution effects on plants and trees
   http://www. Forestrynepal.org/notes/silviculture/locality-factors/16
2. Impacts of water pollution on crop growth in Taiwan: Phytotoxic nature of six rivers and twenty seven industrial waste waters in Kaohsiung area, Taiwan: Chang-Hung Chou, Yueh-
   Chin Chiang and Chin-I kao; Bot.Bull. Academia Sinica 19; 107-124(1978)
3. Risk Assessment of heavy metals Contamination in paddy soil, plants and grains(Oryza sativa L.) at the East Coast of India: Deepmala Satpathy, M.Vikram Reddy and Soumya Prakash Dhal;
   Bio Med research International: Vol 2014(2014) pp11
   http://dx.doi.org/10.1155/2014/545473

4. Effect of long-term sewage water irrigation on micro-nutrient and heavy metal content in soil and plants under Musi River Basin in Hyderabad: K. Usha Rani, k.L.Sharma, k.Naga Sri, D.Suma Chandrika, V.L.Savithri and Munnalal; Jr. of Industrial Pollution Control: 30(1)(2014)pp7-22
www.envirobiotechjournal.com
5. Musi River Pollution its impact on health and economic conditions of downstream villages-A Study:Pullaiah Cheepi ;IOSR Journal of Environmental Science, Toxicology and Food technology;1(4) (2012)pp40-51
www.iosrjournals.org
6. Water resources for livestock in Ethiopia: Implications for Research and Development: Zinash Sileshi, Azaze Tegegne and Genet Teckle Tsadik;
MOWR/ EARO/IWMI/ ILRI Workshop; 66-80 pdf. Adobe Reader
7. Effects of Contaminants on Birds; Gary H.Heinz and Stanley N. Wiemeyer
00000260-23.pdf-Adobe Reader,9pages
8. Effects of water pollution; pdf- Adobe Reader.3pages
9. Health Impacts of water pollution; pdf-Adobe Reader. 4pages
http://edugreen.teri-res.in/explore/water/health.htm
10. Livestock Drinking Water and Fish; Clay Campbell P. Ag. 16 pages
Farmland –Riparian Interface Stewardship Programme-FRISP; BC Cattlemen's Association (BCCA)
Livestock_ drinking_ water_ brochure.pdf_ Adobe Reader
11. Livestock's role in water depletion and pollution, 56 pages
A0701e04.pdf-Adobe Reader
12. Drinking water in Gram Panchayats: Ministry of Panchayati Raj, Government of India. 2014.
13. APHA, Clescerl, Leonore S (Editor), Greenberg, Arnold E (Editor), Eaton, Andrew D. (Editor), "Standard Methods for the Examination of water and Waste water" (20th ed.)American Public Health Association). Washington. DC 2008
14. Water Quality: An Integrated global Crisis: Cecilia Jortajada and Asit K. Biswas; Newyork Times, 2013
15. Comparative studies of D.O., B.O.D., and C.O.D., of Godavari River at Nanded and Rajamundry; V.Srinivasa Rao and A.M.Khan; Jr.of Industrial Pollution Control: Enviro Media: 24(1)2008;