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Characterisation of ground waters for metal ions, pesticide residues and microbial content in selected agro based rural habitations in East Godavari region for quality evaluation

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Abstract: The purpose of the present study is to provide a better understanding of the impacts of agricultural activities on ground water quality in some selected agro based rural habitations in East Godavari region of Andhra Pradesh, India. Ground water samples were collected from the nearby locations in the vicinity of agricultural activity areas and characterized for metal ions to assess metal toxicity, Pesticide residues to assess their impacts on ground water quality. The ground waters were analyzed for bacterial species to estimate the microbial contamination. The analytical results revealed that the concentration of metal ions is within the permissible limits of drinking water standards indicating the absence of metal toxicity in waters. The pesticide residue levels are at below detectable limit and can cause no concern on ground water quality. However, the waters are observed with bacterial species which can cause waterborne diseases. The waters are to be treated properly to remove the microbial contamination to protect the public residing in the nearby habitations who consume these waters for drinking or domestic purposes.

Key words: Ground Water; Metal ion; Pesticide; Bacteria; Characterization

Introduction

Ground water contamination is always the result of Human activities. Agricultural activities contribute to ground water exploitation and increase the risk of quality degradation in shallow aquifers[1] particularly in coastal areas[2]. Pesticide and herbicide applications on crops contribute to chemical deposit in soil which are carried through runoff and leaching into rivers, lakes and ground waters. [3&4] In case of pesticide it has been estimated that less than 0.1% of the product applied to crops actually reaches the target pest and the rest enters the environment and contaminate soil and water and air where it can poison the not target organisms.[5] The presence of pesticides in ground water has been documented in several monitoring programmes and numerous investigations.[6,7] The studies of B. Marouane *et al.,* revealed that no pesticide are detected in ground water quality near agricultural practice areas. [8] Mannure runoff due to rain fall may carry pathogens like bacteria and viruses to water bodies affecting water quality for both aquatic life and humans.[9,10] Pathogenic microorganisms are responsible for causing infectious diseases in humans and are major cause of decline and destruction of coral reefs worldwide [11, 12]. The metal dissolved in water has the greatest potential of causing the most deleterious effects[13]. The contaminants like heavy metals affect the water bodies due to their strong toxicity even at low concentrations[14]. The sampling locations are identified in the nearby agricultural activity areas selected for the present research study are located in East Godavari region of Andhra Pradesh and the details are presented in Table 1.

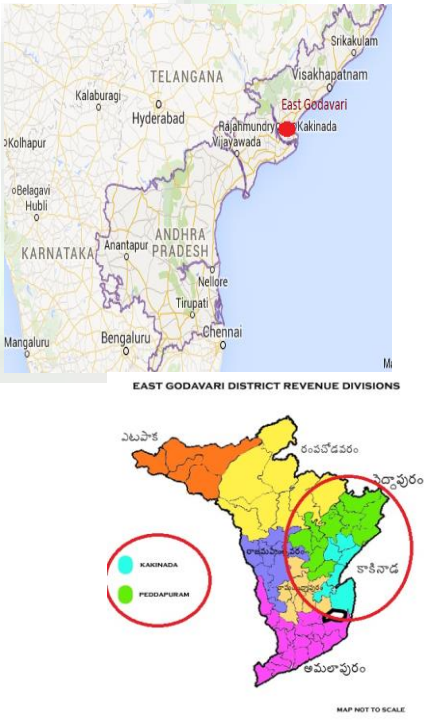

Figure 1: Study area Map

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Table 1: Sample code and Sampling locations

Sample Code	Mandal HQ	Sample Location	Location Coordinates Longitude	Lattitude
		Kakinada Division		
K-1	Kakinada	Venkatapuram	N17⁰03.320¹	E82⁰15.040¹
K-2	Samalkot	Pavara	N17⁰04.391¹	E82⁰14.869¹
K-3	Pithapuram	Narasimhapuram	N17⁰04.411¹	E82⁰14.867¹
K-4	Gollaprolu	Gollaprolu	N17⁰04.411¹	E82⁰14.867¹
K-5	Pedapudi	Rameswaram	N16⁰58.884¹	E82⁰11.992¹
K-6	Karapa	Penukuduru	N16⁰54.253¹	E82⁰12.166¹
		Peddapuram Division		
P-1	Peddapuram	Peddapuram	N17⁰13.785¹	E82⁰12.205¹
P-2	Gandepalli	Surampalem	N17005.0921	E82⁰01.474¹
P-3	Jaggampeta	Jaggampeta	N17⁰09.912¹	E82⁰03.661¹
P-4	Yeleswaram	Yerravaram	N17⁰13.901¹	E82⁰07.372¹
P-5	Kirlampudi	Kirlampudi	N17⁰13.461¹	E82⁰11.254¹
P-6	Prathipadu	Prattipadu	N17⁰13.784¹	E82⁰12.204¹
P-7	Shankavaram	Kattipudi	N17⁰14.268¹	E82⁰19.843¹
P-8	Tondangi	Kothapalli	N17⁰14.269¹	E82⁰19.842¹
P-9	Tuni	Timmapuram	N17⁰02.155¹	E82⁰15.038¹

Materials and Methods

Polythene containers were employed for sampling and preserved for analysis by following the standard procedures [15]. The representative Ground water samples collected were analyzed for metal ions viz., Be, al, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Ag, Cd, Ba and Pb by Inductive coupled Plasma Mass Spectrometry (ICPMS) technique Model-7700 Make- Agilent Technologies. Analysis of ground water samples is possible using the 7700, ICP-MS. Samples are diluted with milli equivalent water, maintain conductance less than 1000µs/cm and acidified with 100µL of supra pure HNO_3. Rh used as Internal Standard (ISTD) and the samples are processed as per the manual instructions of the instrument and introduced into the instrument and analyzed. The instrument has capacity of generating the concentration levels of 23 metals.

Microbial Analysis

The ground water samples are collected in sterilized containers[9] and immediately processed for analysis for determining the MPN count and for detecting the bacterial spps. The Most Probable Number (MPN) technique has been employed for the enumeration for the *Coliform* count in water samples[15,16] which involved the presumptive test using lactose broth and Nutrient Agar, confirmatory test using Eosin Methylene Blue (EMB) agar, pure colonies of the isolated were subjected to grams stain, motility, Indole, Methyl red, Voges-Proskuer test, Citrate utilization test, Urease test, Catalase and Oxidase test.[18]

Pesticide Residual by GC/MSD: (Organo Phosphorous pesticides)

Instrument ID No; LLPL/CHEM/GC-MS/SLN-CN10946108, Test Method: USEPA 525.2

Sample Preparation: Take 1000ml of water in the separatory funnel. Activate C18 *cartridge with 10ml methanol and 10ml water for catridge conditioning. Pass the sample through *cartridge 10ml/min flow rate. Finally elute the compound with 10ml DCM and with 10ml of ethyl acetate. Concentrate the eluents to 1ml sample. Inject 1µl to GC-MS.

Instrument conditions:

Carrier Gas: Helium (Grade-I)
Column: HP-5 (30M X 0.25mm X 0.25µm)
Column ID No: LLPL/GC/C-COL/003
Flow rate: 1.0ml/min;
Injection Temp: 250⁰C;
Injection volume: 1µL
GC oven programme:
Initial temp: 100⁰C for 0.5min
Rate: 7⁰C /min/ to 280⁰C hold for 3.0min,
MS Conditions:
Detector: MSD-5975C
Quadrapole Temp: 150⁰C
MS Mode: SIM
Ion Source temp: 230⁰C
MS Transfer line: 280⁰C;
Stock concentration: 1ppm
Standards used for calibration: 50ppb, 100ppb, 200ppb, 500ppb.

Pesticide Residual by GC-ECD: (Organo Chlorine pesticides)

Instrument ID No; LLPL/CHEM/GC-MS/SLN-CN10451155; Test Method: USEPA 508

Sample Preparation: Volume of water taken 1000ml in the separator funnel. Add about 30gm of sodium chloride. Add 60ml of methylene chloride, extract for 2min repeat the extractions two more times, and then combine all the three extracts and concentrate to a final volume of 1ml sample. Inject 1µL to GC-ECD.

Instrument conditions:

Carrier Gas: Helium (Grade-I);
Column: HP-5 (30M X 0.25mm X 0.25µm)
Column ID No: LLPL/GC/C-COL/002
Flow rate: 1.0ml/min;
Injection Temp: 250⁰C;
Injection volume: 1µL auto injection

GC oven programme:
Initial temp: 100^{0}C for 0.5min;
Rate-1: 7^{0}C /min/ to 290^{0}C hold for 2.0min;
MS Conditions:
Detector: ECD;
Detector Temp: 330^{0}C;
Stock concentration: 1ppm
Standards used for calibration: 20ppb, 50ppb, 100ppb, 200ppb, 500ppb.

Table 2: Metal ion concentration of ground Waters-Kakinada Division

S.NO.	Be (ppm)	Al (ppm)	Cr (ppm)	Mn (ppm)	Fe (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)	Ag (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)
K-1	0.000006	0.003345	0.001397	0.001514	0.062235	0.000026	0.00056	0.00123	0.002091	0.00097	0.000017	0.000009	0.002221	0.000227
K-2	0.000007	0.002039	0.00104	0.000627	0.063356	0.000119	0.001158	0.002294	0.001015	0.002904	0.000026	0.000011	0.012571	0.000159
K-3	0.00001	0.01529	0.001902	0.00208	0.083269	0.000154	0.003634	0.015055	0.005562	0.001255	0.000097	0.000025	0.118024	0.002266
K-4	0.000004	0.003364	0.001058	0.000321	0.065177	0.000066	0.001025	0.003431	0.001054	0.004202	0.000035	0.000009	0.026299	0.000127
K-5	0.000004	0.004945	0.002582	0.000423	0.05676	0.000082	0.001264	0.000749	0.00102	0.002419	0.000015	0.00001	0.075334	0.000119

Table 3: Metal ion concentration of ground Waters-Peddapuram Division

S.NO.	Be (ppm)	Al (ppm)	Cr (ppm)	Mn (ppm)	Fe (ppm)	Co (ppm)	Ni (ppm)	Cu (ppm)	Zn (ppm)	As (ppm)	Ag (ppm)	Cd (ppm)	Ba (ppm)	Pb (ppm)
P-1	0.00001	0.004213	0.002165	0.000594	0.071424	0.000098	0.001203	0.00092	0.000918	0.001456	0.000025	0.000016	0.11255	0.000172
P-2	0.000041	0.004362	0.001819	0.000632	0.078945	0.000128	0.000952	0.001074	0.001134	0.000722	0.000064	0.00004	0.136431	0.000171
P-3	0.000002	0.003549	0.001376	0.000317	0.076403	0.000115	0.001379	0.002507	0.001591	0.002154	0.000056	0.000011	0.029675	0.000428
P-4	0.000024	0.00457	0.001165	0.000566	0.087473	0.000125	0.000803	0.001431	0.001285	0.001762	0.000064	0.000027	0.033469	0.000306
P-5	0.000029	0.004811	0.001133	0.001353	0.079741	0.000069	0.001026	0.001217	0.0035	0.001414	0.000065	0.00005	0.03523	0.000577
P-6	0.000004	0.002011	0.000918	0.000223	0.052941	0.000028	0.001072	0.00151	0.002023	0.001044	0.000025	0.00002	0.023046	0.00017
P-7	0.000006	0.002635	0.000918	0.000273	0.062423	0.000154	0.00107	0.001511	0.001439	0.00228	0.000026	0.00002	0.082054	0.000108
P-8	0.000005	0.002232	0.001401	0.000271	0.071305	0.000241	0.001625	0.005377	0.001122	0.005867	0.000044	0.000012	0.083744	0.000131
P-9	0.000007	0.008521	0.001767	0.000589	0.075556	0.000712	0.00332	0.006031	0.001873	0.005865	0.000035	0.000018	0.165836	0.000284

Table 4: Details Bacterial species of ground Waters – Kakinada Division

Sample code	MPN Count/100ml	No.of Bacterial Colonies	Bacterial colony morphology on EMB	Gram Stain	Motility	Biochemical Tests							Bacteria identified
						Indole	MR	VP	Citrate	CA	OX	UR	
K-1	6	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		2	Light pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
K-2	34	1	Colour less	-ve	Motile	-ve	-ve	-ve	-ve	-ve	+ve	-ve	*Pseudomonas*
K-3	5	1	Colour less	-ve	Motile	-ve	-ve	-ve	-ve	-ve	+ve	-ve	*Pseudomonas*
K-4	540	1	Metallic sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.coli*
		2	Colour less	-ve	Motile	-ve	-ve	-ve	-ve	-ve	+ve	-ve	*Pseudomonas*
K-5	920	1	Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
K-6	>1800	1	Metallic sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.coli*
		2	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		3	Pink Mucoid	-ve	Non Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*

Table 5: Details Bacterial species of ground Waters – Peddapuram Division

Sample code	MPN Count/100ml	No.of Bacterial Colonies	Bacterial colony morphology on EMB	Gram Stain	Motility	Biochemical Tests							Bacteria identified
						Indole	MR	VP	Citrate	CA	OX	UR	
P-1	2	1	Metallic sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.coli*
		2	Light Pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
		3	Pink mucoid	-ve	Non Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
P-2	>1800	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		2	Pink mucoid	-ve	Non Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
P-3	>1800	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		2	Pink mucoid	-ve	Non Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*
P-4	1600	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		2	Light pink	-ve	Motile	-ve	+ve	-ve	-ve	+ve	-ve	+ve	*Proteus*
P-5	18	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
P-6	920	1	Metallic sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.coli*
		2	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
P-7		1	Metallic sheen	-ve	Motile	+ve	+ve	-ve	-ve	+ve	-ve	-ve	*E.coli*
P-8	<2	Portable											
P-9	170	1	Purple centered	-ve	Motile	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Enterobacter*
		2	Pink Mucoid	-ve	Non	-ve	-ve	+ve	+ve	+ve	-ve	-ve	*Klebsiella*

Results and Discussions

Metals

The metal ion concentrations in ground waters both in Kakinada and Peddapuram revenue divisions are within the permissible limits of drinking water standards. And hence can cause no concern on the quality of ground water near agricultural activity areas.

Pesticides

The concentrations of pesticide viz., Alpha Endosulfan, Beta Endosulfan, Endosulfan sulphate and Monocrotophos in ground water samples in study areas of Kakinada and Peddapuram revenue divisions are at Below Detectable Levels (BDL) causing no concern on ground water quality.

Table 6: Kakinada division Sample K-3

S.No.	Parameter	Units	Results	Test Method
1	Alpha Endosulfan	mg/l	BDL	USEPA 508
2	Beta Endosulfan	mg/l	BDL	USEPA 508
3	Endosulfan sulphate	mg/l	BDL	USEPA 508
4	Monocrotophos	mg/l	BDL	USEPA 525.2

Table 7: Peddapuram division Sample P-1

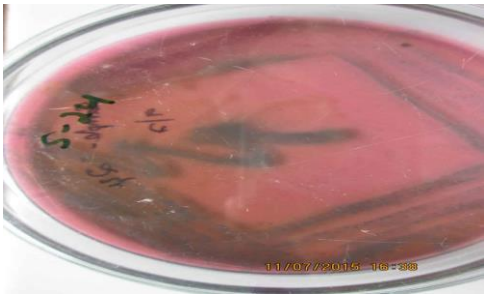
S.No.	Parameter	Units	Results	Test Method
1	Alpha Endosulfan	mg/l	BDL	USEPA 508
2	Beta Endosulfan	mg/l	BDL	USEPA 508
3	Endosulfan sulphate	mg/l	BDL	USEPA 508
4	Monocrotophos	mg/l	BDL	USEPA 525.2

Bacterial Contamination

The ground waters near agricultural activity areas in villages Venkatapuram, Pavara, Narasimhapuram, gollaprolu, Rameshwaram and penukuduru of Kakinada, Samalkot, Pithapuram, Gollaprolu, Pedapudi and Karapa mandal headquarters are found to be present with pathogenic bacterial species viz., *Enterobacter, Proteus, Pseudomonas, E.coli,* and *Klebsiella* which contribute water born diseases like Fever, Typhoid, Decentre etc.,

Figure 2: Photographs of Bacterial species identified in Ground Water samples

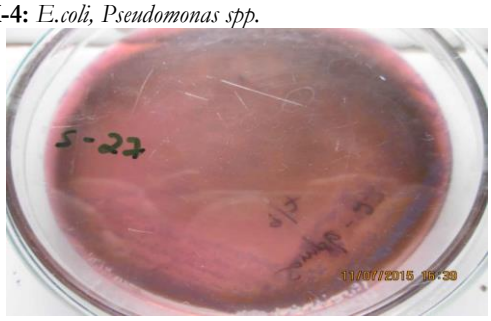
K-1: *Enterobacter, Proteus spp.*



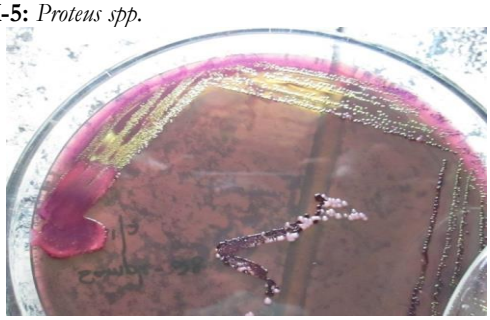
K-2: *Pseudomonas spp.*

K-3: *Pseudomonas spp.*

K-4: *E.coli, Pseudomonas spp.*



K-5: *Proteus spp.*

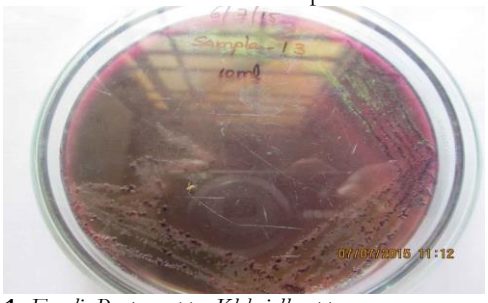


K-6: *E.coli, Enterobacter spp., Klebsiella spp.*

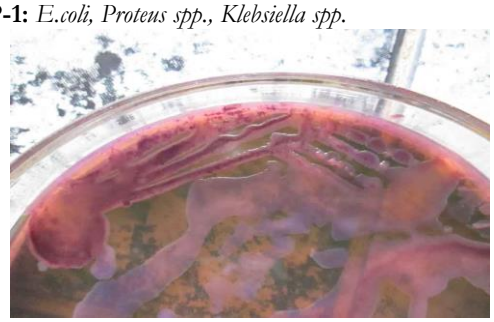
The ground waters near agricultural activity areas in villages Peddapuram, Surampalem, Jaggampeta, Yerravaram, Kirlampudi, Prattipadu, Kattipudi, Kothapalli and Timmapuram of Peddapuram, Gandepalli, Jaggampeta, yeleswaram, Kirlampudi, Prathipadu, Shankavaram, Tondangi and Tuni mandal headquarters are found to be present with pathogenic bacterial species viz., *Enterobacter,*

Proteus, Pseudomonas, E.coli, and Klebsiella which contribute water born diseases like Fever, Typhoid, Decentre etc.,

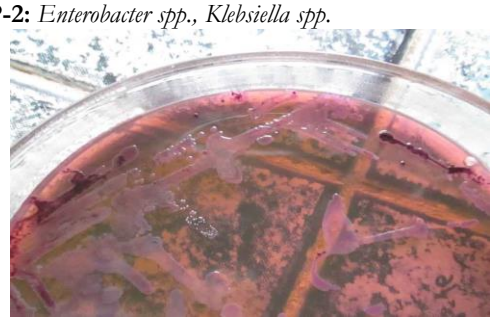
Figure 3: Photographs of Bacterial species identified in Ground Water samples



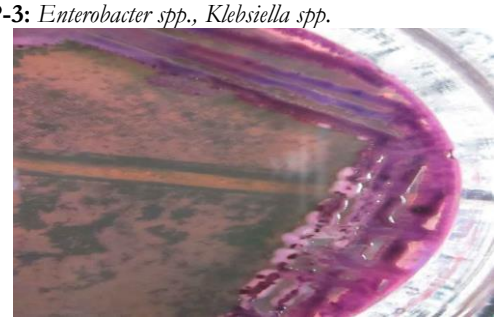
P-1: *E.coli, Proteus spp., Klebsiella spp.*



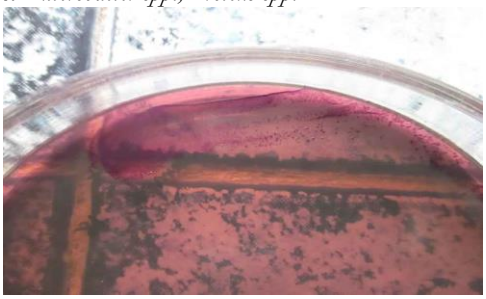
P-2: *Enterobacter spp., Klebsiella spp.*



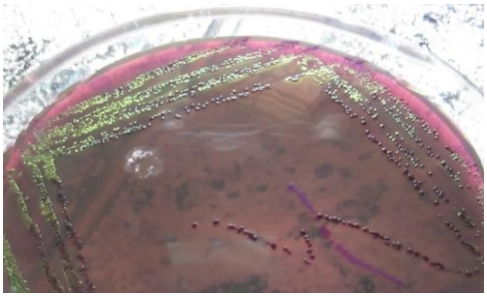
P-3: *Enterobacter spp., Klebsiella spp.*



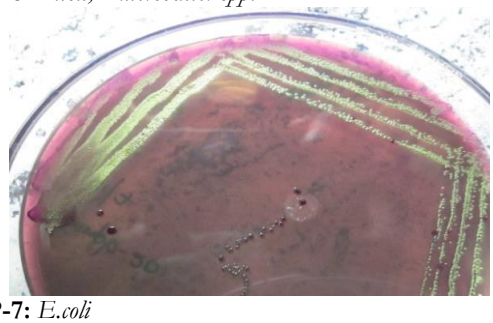
P-4: *Enterobacter spp., Proteus spp.*



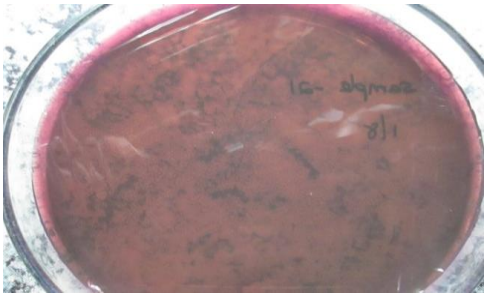
P-5: *Enterobacter spp.*



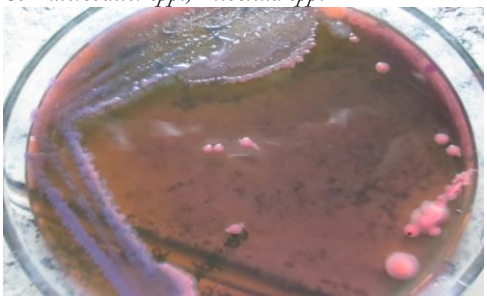
P-6: *E.coli, Enterobacter spp.*



P-7: *E.coli*



P-8: *Enterobacter spp., Klebsiella spp.*



P-9: *Enterobacter spp., Klebsiella spp.*

Conclusion

The metal ion concentrations in ground waters near agricultural activity study areas in Kakinada and Peddapuram are within the permissible limits of drinking water standards indicating non toxicity of metals in waters. The concentration of pesticides Alpha Endosulfan, Beta Endosulfan, Endosulfan sulphate and Monocrotophos in ground water samples in study areas of Kakinada and Peddapuram revenue divisions are at Below Detectable Levels (BDL) indicating that the ground waters are free from pesticide redidues. However, the ground waters are found to contain bacteria species like *Enterobacter, Proteus, Pseudomonas, E.coli* and *Klebsiella spp.* which contribute microbial contamination to the waters and can cause waterborne diseases like typhoid, dysentery, fever, jaundice etc., the ground waters

are to be properly treated for the removal of bacterial contamination before use for protection of the health of the public residing in the vicinity of rural agriculture activity habitations.

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