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EVALUATION OF METAL AND BACTERIAL CONTAMINATION OF GROUND WATERS IN AGRICULTURE AND AQUACULTURE ACTIVITY AREAS OF WEST GODAVARI DISTRICT

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ABSTRACT

Groundwater is the main source for drinking purposes. Agriculture and Aquaculture activities are the major sources of human food. Various chemicals like fertilizers, pesticides, pH modifiers, and nutrients are being employed to enhance crop yields. Due to the excessive application of these chemicals, the ground waters in the surrounding areas will be contaminated. Keeping in view the hectic agriculture and aquaculture activities it is aimed to evaluate the metal and bacterial contamination status in waters for suggesting the possible remedial measures to protect the public. From the proposed study area, 16 Groundwater samples were collected and analyzed for metal ion concentrations. Further the waters are also analyzed for evaluating the bacterial contamination. The study results revealed that the waters were found to contain MPN count along with water-borne disease-causing pathogens. These waters are needed to be subject to suitable treatment techniques available for considering these waters for drinking and domestic purposes.

Keywords: Ground Water, Agriculture, Aquaculture, Metal, Microbial Contamination.

INTRODUCTION

Metals contamination due to industrial, municipal, and urban runoff can cause harm to human health as well as biotic life. Enhancement in urbanization and industrialization can cause an increase in levels of heavy metals in water sources.[1] Toxic chemicals entering the environment will accumulate in water sources.[2] The degree of toxicity varies depending on the metal, its biological origin, and the sort of organisms with which it interacts.[1] Metal toxicity will have an impact on aquatic flora and fauna and bio-magnifies and enter the food chain and cause concern for human health.[3] The presence of heavy metals viz., lead, iron, cadmium, copper, zinc, chromium, etc., in drinking water, often affect human health. Metal ions such as Hg, Cd, As, Cr, Tl, Zn, Ni, Cu, and Pb are common contaminants in water sources. These metals are extensively distributed across the Earth's crust, are non-biodegradable, and enter the human body through air, water, and food. The research results of Sivakumar Karthikeyan *et al* 2021 revealed that increased metal concentrations in groundwater are caused by evaporation, anthropogenic activity, and the disintegration of rock formations, all of which are hazardous to a humans health.[4] Mainly Iron and arsenic from geogenic sources are responsible for groundwater quality deterioration in India from metal contamination.[5-10] The quality of water depends on its physical, chemical, and microbial characteristics. Correlations among these parameters will be useful to indicate the quality of water.[11-14] The use of ground water for irrigation becomes a risk due to the intrusion of saline water from the nearby water sources.[15] Most of the aquaculture practices show adverse effects on ecosystem.[16] To minimize the adverse impact of aquaculture, several measures are to be implemented to safeguard the aquatic environment.[17-19] Chemical contamination of river and ground water is the most serious pollution problem, particularly in arid and semi- arid areas. The excessive utilization of pesticides can cause higher concentration of metal ions in waters.[20] *Coliform bacteria (CB), E. coli*, *Fecal streptococci or Enterococci (EC)* are indicators of fecal contamination and general contamination of waters.[21] Several research studies on microbial contamination of groundwater identified the pathogens which can cause concern for the health of the public when

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consuming contaminated waters for drinking purposes.[22-24] Keeping in view of the hectic agricultural and aquaculture activities in the West Godavari district, it is focused on the assessment of metal toxicity and microbial contamination to evaluate the quality of the groundwater sources to suggest the end-users for considering the water for drinking irrigation and domestic utility.

EXPERIMENTAL

Materials and Methods

Sixteen sampling locations were identified each in Tanuku–Agriculture activity area and the Bhimavaram - Aquaculture activity area and the sampling location details are presented in Table-1. Sampling has been done by following prescribed guidelines for water sample analysis.[25,26] ICP OES (Avio 200 Perkin Elmer-Model) is used for the analysis of metal ions and the details are presented in Table-2, Table-3, Table-4, and Table-5. MPN count in waters, identification of the *bacterial species* along with their shape, and color of the microorganism. Biochemical characterization using IMViC (Indole production test, Methyl red test, Vogesproskauer test, Citrate utilization) tests are followed by adopting standard procedures[27-29] and are shown in Table-6.

Table-1: Sampling Locations Details

Sample Code	Location of Sampling	GPS Co-ordinates	
		Longitude	Latitude
Near Agriculture activity areas – Tanuku			
TNE-1	Near DOC Chemical factory , Eragavaram Road	81.70507	16.71878
TNE-2	Gopalapuram near Dinakaran fabric work, Eragavaram Road	81.70505	16.7258
TNE-3	Gopayyakalava, Kondamma temple , Eragavaram Road	81.70488	16.73272
TNE-4	Tanuku pathuru , Eragavaram colony near School	81.69388	16.74958
TNW-1	No.3 School , Duvva main road	81.62799	16.78205
TNW-2	Eggs attala factory , Duvva main road	81.64907	16.77168
TNW-3	Indian Oil Bunk , Tadepalligudem road	81.64192	16.77599
TNW-4	Rambadra Rice mill , Tatali, Tadeplligudem road	81.66235	16.76316
TNN-1	Rohini Milk dairy farm, near Andhra Bank	81.69851	16.7856
TNN-2	Anjanaya swami temple, Nidadavolu road	81.70045	16.78853
TNN-3	Kanakadurga temple, near church , Nidadavolu road	81.70016	16.78689
TNN-4	Palangi , near DLG poultry , Indian oil bunk	81.72126	16.76579
TNS-1	Veerabadrapuram, near reddy complex	81.67627	16.72987
TNS-2	Indian oil petrol bunk, Velpuri road	81.67536	16.7262
TNS-3	Kavalipuram road, Velpuri road	81.67096	16.70963
TNS-4	HP gas Godowns (Kavalipuram) , Velpuri road	81.67439	16.73581
Near Aqua culture activity areas – Bhimavaram			
BE-1	Rajulapeta, Ramalayam, Murthy nagar	81.55252	16.54895
BE-2	Rajulapallam, pp road, near Ajanayaswami temple	81.55311	16.55052
BE-3	Bokkavaripeta (Vissakoderu), SLV Towers	81.55641	16.54928
BE-4	Visskoderu , Mallemvari street	81.56075	16.5502
BW-1	Undi road near (Achari Engineering works)	81.49945	16.55876
BW-2	Undi road(near venkataratnam rice mill)	81.49947	16.55871
BW-3	Undi road (near venkataratnam rice mill)	81.49947	16.55879
BW-4	Undi road, near ropping industry	81.49925	16.55980
BN-1	Gollalakoderu ,near Vinyaka Temple	81.52839	16.57424
BN-2	Garagaparru road, near Durgammagudi	81.53044	16.6076
BN-3	Garagaparru road, near Ramalayam	81.52940	16.60827
BN-4	Pippara road , near Appaannapeta	81.53656	16.6781
BS-1	Taderu , Narsapuram road	81.53721	16.53433

BS-2	Taderu , Narsapuram road	81.53713	16.5344
BS-3	High school, near Taderu	81.53718	16.5344
BS-4	Near High school (Subramanyam Temple)	81.53962	16.51702

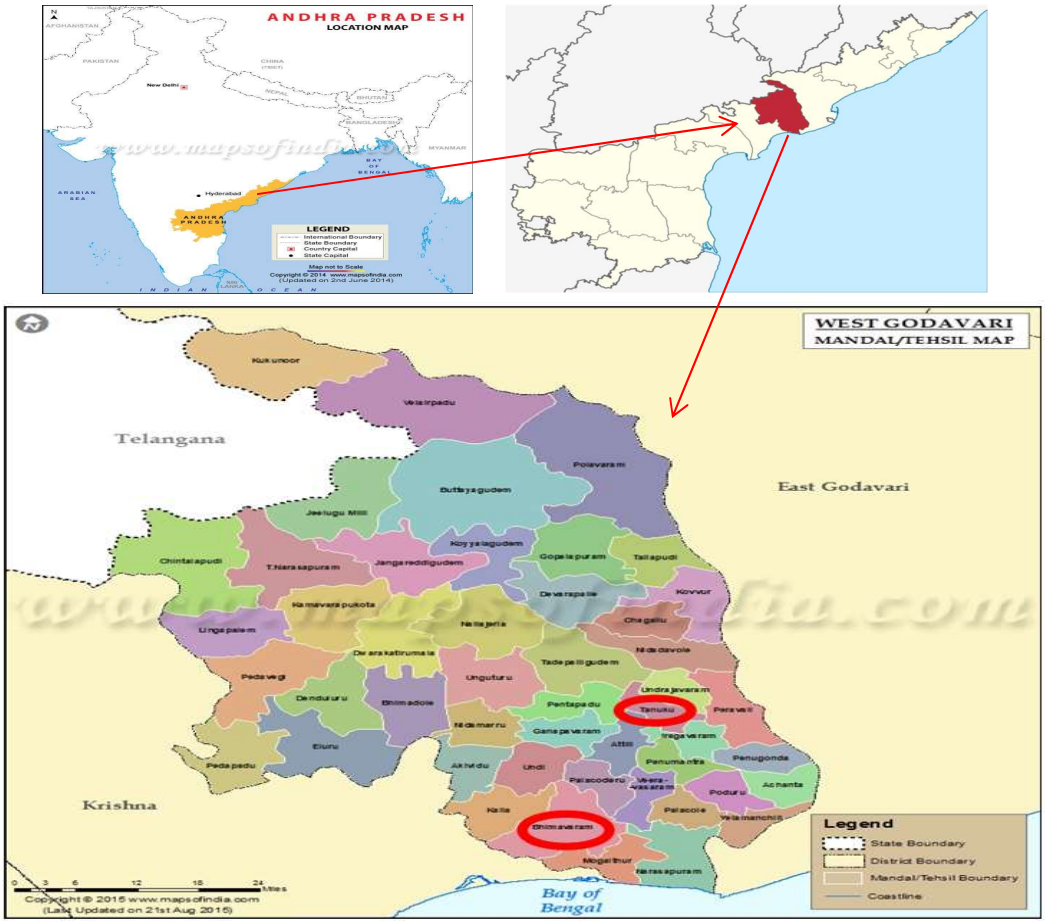

Fig.-1: Study Area Map.[30] (source: www.mapsofindia.com)

RESULTS AND DISCUSSION

Metal ions in Waters near Aquaculture Activity Area

Concentrations of Fe, Co, Ni, Cr, Pb, Cu, and Hg present in waters of both seasons are observed <5.0 ppb. Manganese concentrations are found to be 11.37 ppb in BE, 48.87 ppb in BW, 11.13 ppb in BN, and 14.14 ppb in BS samples respectively in pre-monsoon. In post-monsoon Mn, values are <5.0 ppb in BE, BW, and BN samples and 6.689 ppb in BS samples. Manganese in all these waters is less than the permissible limit (50 ppb) of WHO. The arsenic concentration was found to be 6.239 ppb in BE, 10.89 ppb in BW, 13.16 ppb in BN, and 11.18 ppb in BS samples of pre-monsoon waters. In post-monsoon as values were observed as 5.9679 ppb in BE, 6.812 ppb in BW, 11.51 ppb in BN, and 8.528 ppb in BS. Among all water samples, BW, BN, and BS in pre-monsoon, BN in post-monsoon exceeded the permissible limit WHO.

Table-2: Metal ion Concentration of Groundwater near Aquaculture Activity Area: Pre-Monsoon

S.No.	Parameter	Unit	Sample Particular				Method Followed
			BE	BW	BN	BS	
1.	Chromium as Cr	ppb	<5.0	<5.0	<5.0	<5.0	APHA, 3120-B, 23rd Edition
2.	Manganese as Mn	ppb	11.37	48.87	11.13	14.14	
3.	Iron as Fe	ppb	<5.0	<5.0	<5.0	<5.0	
4.	Cobalt as CO	ppb	<5.0	<5.0	<5.0	<5.0	

5.	Nickel as Ni	ppb	<5.0	<5.0	<5.0	<5.0
6.	Copper as Cu	ppb	<5.0	<5.0	<5.0	<5.0
7.	Zinc as Zn	ppb	<5.0	<5.0	<5.0	<5.0
8.	Lead as Pb	ppb	<5.0	<5.0	<5.0	<5.0
9.	Arsenic as As	ppb	6.239	10.89	13.16	11.18
10	Mercury as Hg	ppb	<5.0	<5.0	<5.0	<5.0

Table-3: The metal ion Concentration of Groundwater near Aquaculture Activity Area - Post Monsoon

S. No.	Parameter	Unit	Sample Particular				Method Followed
			BE	BW	BN	BS	
1.	Chromium as Cr	ppb	<5.0	<5.0	<5.0	<5.0	APHA, 3120-B, 23rd Edition
2.	Manganese as Mn	ppb	<5.0	<5.0	<5.0	6.689	
3.	Iron as Fe	ppb	<5.0	<5.0	<5.0	<5.0	
4.	Cobalt as CO	ppb	<5.0	<5.0	<5.0	<5.0	
5.	Nickel as Ni	ppb	<5.0	<5.0	<5.0	<5.0	
6.	Copper as Cu	ppb	<5.0	<5.0	<5.0	<5.0	
7.	Zinc as Zn	ppb	<5.0	<5.0	<5.0	<5.0	
8.	Lead as Pb	ppb	<5.0	<5.0	<5.0	<5.0	
9.	Arsenic as As	ppb	5.969	6.812	11.51	8.528	
10	Mercury as Hg	ppb	<5.0	<5.0	<5.0	<5.0	

Table-4: The metal ion Concentration of Groundwater near Agriculture Activity Area - Pre Monsoon

S. No.	Parameter	Unit	Sample Particular				Method Followed
			TNE	TNW	TNN	TNS	
1.	Chromium as Cr	ppb	<5.0	<5.0	<5.0	<5.0	APHA, 3120-B, 23rd Edition
2.	Manganese as Mn	ppb	<5.0	<5.0	<5.0	<5.0	
3.	Iron as Fe	ppb	<5.0	<5.0	<5.0	<5.0	
4.	Cobalt as CO	ppb	<5.0	<5.0	<5.0	<5.0	
5.	Nickel as Ni	ppb	<5.0	<5.0	<5.0	<5.0	
6.	Copper as Cu	ppb	<5.0	<5.0	<5.0	<5.0	
7.	Zinc as Zn	ppb	<5.0	<5.0	<5.0	<5.0	
8.	Lead as Pb	ppb	<5.0	<5.0	<5.0	<5.0	
9.	Arsenic as As	ppb	10.86	11.84	10.07	10.93	
10	Mercury as Hg	ppb	<5.0	<5.0	<5.0	<5.0	

Table-5: The metal ion Concentration of Groundwater near Agriculture Activity Area – Post Monsoon

S. No.	Parameter	Unit	Sample Particular				Method Followed
			TNE	TNW	TNN	TNS	
1.	Chromium as Cr	ppb	<5.0	<5.0	<5.0	<5.0	APHA, 3120-B, 23rd Edition
2.	Manganese as Mn	ppb	<5.0	<5.0	<5.0	<5.0	
3.	Iron as Fe	ppb	<5.0	<5.0	<5.0	<5.0	
4.	Cobalt as CO	ppb	<5.0	<5.0	<5.0	<5.0	
5.	Nickel as Ni	ppb	<5.0	<5.0	<5.0	<5.0	
6.	Copper as Cu	ppb	<5.0	<5.0	<5.0	<5.0	
7.	Zinc as Zn	ppb	<5.0	<5.0	<5.0	<5.0	
8.	Lead as Pb	ppb	<5.0	<5.0	<5.0	<5.0	
9.	Arsenic as As	ppb	11.19	12.90	9.777	12.03	
10	Mercury as Hg	ppb	<5.0	<5.0	<5.0	<5.0	

Metal Ions in Waters near Agriculture Activity Area

Concentrations of Fe, Co, Cr, Mn, Ni, Cu, Pb, Zn, and Hg present in waters of both seasons were found < 5.0 ppb. Arsenic concentrations are observed as 10.86 ppb in TNE, 11.84 ppb in TNW, 10.07 ppb in TNN, and 10.93 ppb in TNS samples in pre-monsoon. In post-monsoon 11.19 ppb in TNE, 12.90 ppb in TNW, 9.777 ppb in TNN, and 10.93 ppb in TNS samples in pre-monsoon. In post-monsoon 11.19 ppb in TNE, 12.90 ppb in TNW, 9.777 ppb in TNN, and 12.03 ppb in TNS samples. The Arsenic values of waters indicate that the majority of waters crossed the permissible limit (10ppb) of WHO.

Table-6: Details of Microbial Characteristics in Water near the Agriculture Activity Area

Code	MPN	Bacterial Colonies on EMB		Gram's Nature	*(IMViC TESTS)				*Bacteria Species*
		Number	Morphology		I	MR	VP	C	
Near Agriculture									
TNE-1	04	02	Colorless	-ve	-	-	-	-	*Pseudomonas*
TNE-2	02	02			-	-		-	
TNW-1	02	02	Light Pink		-	+		-	*Proteus*
TNW-2	04	01	Colourless		-	-		-	*Pseudomonas*
TNN-1	02	01			+	+		+	*Citrobacter Freundii*
TNN-2	02	02			-	-		-	*Pseudomonas*
TNS-1	02	01			-	-		-	
TNS-2	04	01			-	-		-	
Near Aquaculture									
BE-1	07	01	Brown Center	-ve	-	-	+	+	*Entrobacter*
BE-2	13	02	Colourless		-	-	-	-	*Pseudomonos*
BW-1	02	01	Green Metallic Sheen		+	+		-	*E.coli*
BW-2	25	02	Colourless		+	+		+	*Citrobacter*
BN-1	02	01			-	-		-	*Pseudomonos*
BN-2	11	01			+	+		+	*Citrobacter*
BS-1	23	02	Green Metallic Sheen		+	+		-	*E.coli*
BS-2	23	02			+	+		-	

**I = Indole, MR=Methyl red, VP=Voges Proskauer, C=Citarte*

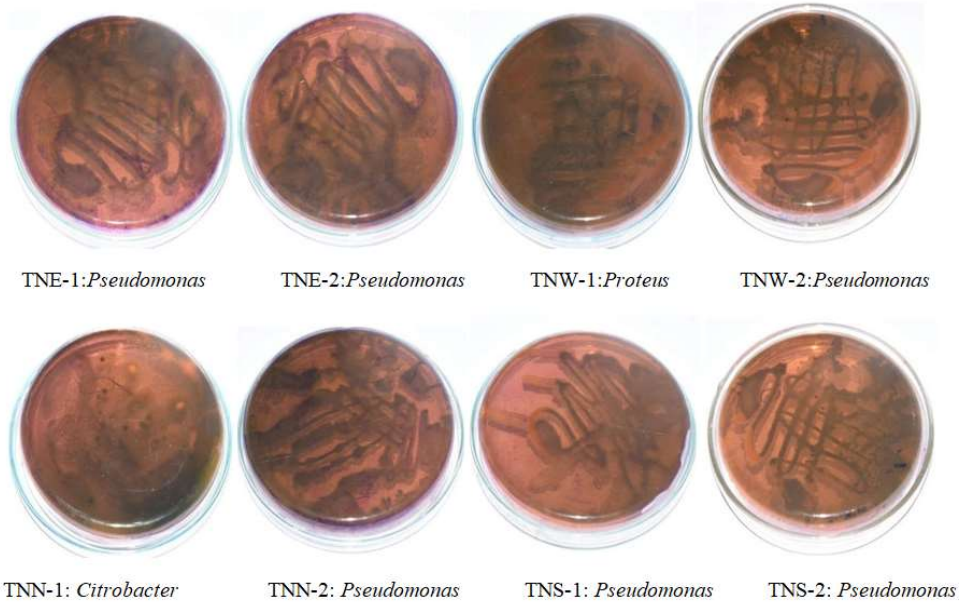

Fig.-2: Identified Microbial Species Photographs

Microbial Characterization of Waters

Near Agriculture

The MPN count was found as 4 in TNE-1 with identified bacterial species *Pseudomonas,* 2 in TNE-2 with bacterial species *Pseudomonas, 2 in* TNW-1with Proteus *bacterial species*, 4 in TNW-2 with bacterial species *Pseudomonas*, 2 in TNN-1 *with bacterial species Citrobacrter freundii* and 2 in water sample TNN-2 with *bacterial species Pseudomonas* MPN count of Waters TNS-1 is 2 with identified bacterial species Pseudomonas, TNS-2 is 4 with bacterial species identified as *Pseudomonas*.

Near Aquaculture

The MPN count of waters BE-1 was found to be 7 with *bacterial species Entrobacter* and that of BE-2 is 13 with *bacterial species* identified as *Pseudomonas*. MPN count of BW-1 is 2 with *E.Coli as* identified *bacterial species*, and BW-2 is 25 with *bacterial species Citrobacter*. MPN count in BN-1 is 2 with *bacterial species* identified as *Pseudomonas in* BN-2 is 11 with *bacterial species* identified as *Citrobacter*. MPN count of Water sample BS-1 is 23 with *bacterial species* identified as *E.Coli* and that of BS-2 is 23 with *bacterial species* identified as *E.Coli.*

Health Survey

A survey on people of different age's sufferings due to various health issues in the present study area has been done and the data is presented in Table-7.

Table-7: People's Age and Disease Experienced in Aquaculture and Agriculture Activity Areas

Age in Years	Near Aquaculture						Near Agriculture					
	Diseases Experienced					Total	Diseases Experienced					Total
	F	GI troubles	JP	T	SA		F	GI troubles	JP	T	SA	
01-10	12	2	0	2	1	17	8	1	1	3	2	15
11-20	4	1	1	1	0	7	1	1	0	0	1	3
21-30	2	3	0	1	1	8	2	3	2	0	3	10
31-40	6	8	4	0	0	20	3	4	0	1	4	12
41-50	3	2	2	0	1	8	1	2	0	0	3	6
51-60	2	3	2	0	1	8	3	4	0	0	5	12
Above 60	2	1	2	0	1	6	1	0	1	0	1	3
Total	31	20	11	4	5	74	19	15	4	4	19	61

F: Fever, GI: Gastro Intestinal, JP: Joint pains, T: Typhoid and SA: Skin Allergy

According to the results of a health survey, persons who drink these waters have gastrointestinal issues, fever, typhoid, and skin illnesses.

CONCLUSION

Metal ions viz., Fe, Co, Cr, Mn, Ni, Cu, Pb, Zn, and Hg present in these waters are within the guideline values prescribed by WHO. Post monsoon season waters are having higher values of Arsenic concentration which crossed the permissible limit (10ppb) prescribed by WHO which indicates Arsenic contamination of these waters impacts the human cardiovascular system, especially in children. These waters are contaminated with pathogens like *Pseudomonas*, *Citrobacter, E.Coli,* and *Proteus* as they lead to water-borne diseases. The health survey indicates people who consume these waters for drinking purposes are having health issues like typhoid, fever, joint pains, and skin diseases. The research study revealed that these waters are loaded with metal ions and pathogenic microorganisms, they pose a risk to human health if they are utilized for drinking or domestic uses. The health survey data also confirmed the happenings of the present problems being faced by the people consuming these waters for drinking and domestic purposes.

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