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water

Research & Technology

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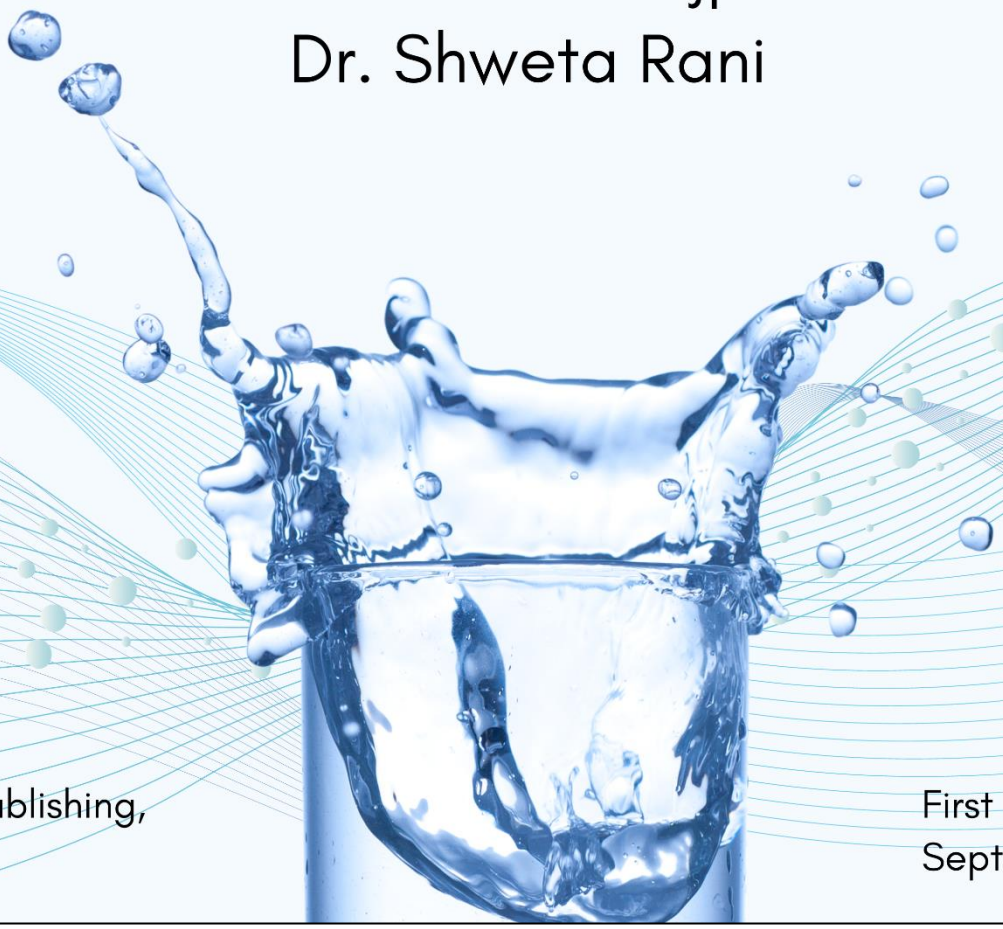

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Water: Research and Technology

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PREFACE

Water is not merely a resource; it is a lifeline sustaining ecosystems, communities, and industries worldwide. As we navigate an era marked by environmental changes, population growth, and technological evolution, understanding and managing water resources become imperative. This book aspires to be a guiding beacon, shedding light on the latest research findings and technological breakthroughs that contribute to the sustainable use and conservation of water.

Our journey begins with an exploration of the fundamental principles governing water—its physical, chemical, and biological properties. From there, we embark on a multidisciplinary voyage encompassing diverse topics such as water quality, treatment processes, and emerging technologies that promise to revolutionize the way we interact with this precious resource.

The contributors to this volume are esteemed experts and researchers, each bringing a wealth of knowledge and experience to their respective chapters. Their collective efforts aim to bridge the gap between theoretical understanding and practical applications, providing readers with valuable insights into the current state of water research and the technological tools available to address contemporary challenges.

We hope this book serves as a valuable resource for students, researchers, professionals, and anyone passionate about water. By fostering a deeper understanding of water-related issues and showcasing innovative technologies, we aspire to inspire a collective commitment to responsible water management.

As we navigate the pages of "Water: Research and Technology," let us remain mindful of our shared responsibility to protect and cherish this invaluable resource. May the knowledge within these chapters contribute to a sustainable and water-secure future for generations to come.

Editors

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Water Research and Technology
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ASSESSMENT OF SEAWATER INTRUSION AND HYDROGEOCHEMICAL CHARACTERIZATION OF GROUNDWATER QUALITY IN KEELAIYUR BLOCK OF NAGAPATTINAM DISTRICT

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Abstract:

Groundwater is being increasingly recognized as a dependable resource to meet the demands of domestic, irrigation and industrial sectors all over the world. The coastal Aquifers of Nagapattinam in recent years witnessed serious groundwater problems. A Hydrogeochemical characterization and seawater intrusion study was carried out in the coastal region of Keelaiyur Block, Nagapattinam District. The study area is lies between North latitudes $10^0$30'30" to $10^0$44'30" and East longitudes $79^0$42'0" to $79^0$49'0". To determine the impacts of seawater intrusion and evaluation of the suitability of groundwater for domestic and irrigation purpose is identified. For this study Forty groundwater samples were collected during pre-monsoon season (July 2017) and post-monsoon season (Jan 2018) and tested for physico-chemical parameters like pH, EC, Hardness, Alkalinity, Chloride, Ca, Mg, Na, K, Phosphate, TDS, Nitrite, Nitrate, SO_4 were identified. The results were compared with WHO standards for drinking purpose and the results show the groundwater samples were not suitable for drinking purpose for both seasons. The results of seawater mixing index show that 47.5% and 70% of the samples were in freshwater category in PRM season and POM season respectively. From the water quality index analysis 40% and 55% of the samples were in good water category in PRMseason and POM season respectively. The results of WATCLAST software shows that the Na%, SAR, RSC, PI and CR of samples were also identified. From this analysis some of the groundwater samples were unsuitable for irrigation purposes.

Keywords: Seawater Intrusion, Physico-Chemical Parameters, WHO Standards, Water Quality Index and WATCLAST.

Introduction:

Water is the most essential and one of the prime necessities of life. Rising demand of water for irrigation, agriculture, domestic and industry is forcing stiff competition over the allocation of scarce water resources. To meet the increasing water demands, reliance on groundwater has been rapidly increasing (Todd, 1959). Groundwater withdrawals in excess of safe yields and reduced recharges to groundwater due to rapidly changing land use pattern along the coasts have significantly increased the incidences of seawater intrusions into the coastal aquifers (Mandal and Shiftion, 1981). Saltwater intrusion is the movement of saline water into freshwater aquifers which can lead to contamination of drinking water sources and other consequences. Saltwater intrusion occurs naturally to some degree in most coastal aquifers, owing to the hydraulic connection between groundwater and seawater. Certain human activities have increased saltwater intrusion in many coastal areas, most importantly groundwater pumping from coastal freshwater wells (Bear *et al.,* 1999). Water extraction drops the level of fresh groundwater, reducing its water pressure and allowing saltwater to flow further inland.

Freshwater is finite resource, essential for agriculture, industry and even human existence, without freshwater of adequate quantity and quality, sustainable development will not be possible. Saltwater intrusion is a major concern commonly found in coastal aquifers around the world. Saltwater intrusion is the induced flow of seawater into freshwater aquifers primarily caused by groundwater development near the coast (Oteri *et al.,* 2003). Saltwater intrusion into coastal aquifers is caused by two mechanisms (Zhang *et al.,* 2001):

- Lateral encroachment from the ocean due to excessive water withdrawals from coastal aquifers.
- Upward movements from deeper saline zones due to up coning near coastal discharge/pumping wells.

Study area:

Nagapattinam is one of the coastal districts of Tamilnadu, in the eastern coast of Bay of Bengal. The district is bounded on the uppanar in the central part and arasalar, vettar, kedurai. The study area keelaiyur block in Nagapattinam extents between $79^{0}42'0"$ E to $79^{0}49'0"$ E and $10^{0}30'30"$N to $10^{0}44'30"$N, it stretches from river Celeron in the north. The study area falls in the survey of India top sheets 58 N/ 14 with a total area of about 184.16 km^2.The study area forms the tail end area of the Cauvery River basin and collide in the

north. The area lying between is Nagapattinam and vedharanyam dominated by sand dunes and cultivated soils are mostly sandy in texture.

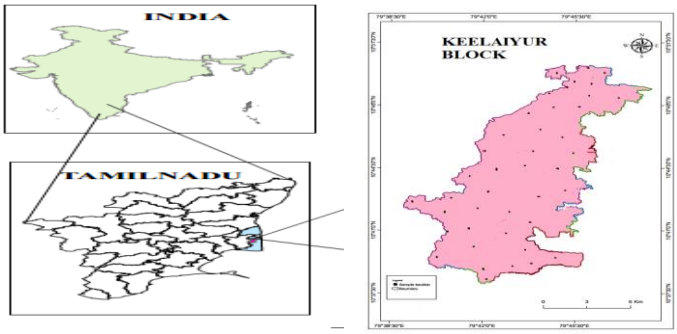

Figure 1: Study area keelaiyur block in Nagapattinam district

Nagapattinam district total area of 2,715.83 $km^{2.}$. Agriculture is the main activity in the district. Paddy, Sugarcane, Coconut and Pulses are the major crops in the district. Velankanni Madhya church is a famous center in Nagapattinam, India. The district normal rainfall is 1230 mm and maximum rainfall of 76%. The study area has tropical climate, the average maximum temperature is 32.46^{0}c. The study area humidity ranges are 70% to 77% (Zhang *et al.,* 2002).

Water sample collection and analysis:

Forty groundwater samples were collected from different bore wells and open wells at every village of keelaiyur block in Nagapattinam district both in post-monsoon season (POM) and pre-monsoon (PRM). For that oneliter of water sample was collected in sterile polythene bottles. The bottles used for sample collection were washed using detergent. After this, the sample bottles were rinsed with distilled. The samples were collected from approximately 80m – 100m below the water surface. The water samples collected in 1L bottle each were transported to our college and analyzed at environmental laboratory. The APHA procedures were adopted for the determination of physico chemical parameters of groundwater samples. After obtained the test results, the results were analyzed with following analysis. The water chemistry analysis is adopted to find the anion and cation sequences of study area. The seawater mixing index is used to find the seawater contamination and WATCLAST analysis is used to identify the water suitability of this region (Li *et al.,* 1999)

Result and Discussion:

1. Water chemistry

The Groundwater samples were analyzed for all the physio-chemical parameters of the study area and results are shown in table 1. The Groundwater in the study area is

alkaline in nature as per the pH value of the study area ranges from 6.9 to 8.8 in PRM season and 6.3 to 8.6 in POM season. All the samples of study areas seem to be within the standard limits. The highest value is note in P. R. Puram 8.8 and keelaiyur 8.6 during this study. Electrical Conductivity values identify between 356 µs/cm to 1371 µs/cm in PRM season and 325 µs/cm to 1238 µs/cm in POM season. All location sample values are higher than the standard values, P. R. Puram shows that the highest value of 1371 µ/cm in PRM season. The alkalinity values of PRM season are 280 mg/l to 675 mg/l and in POM season 250 mg/l to 863 mg/l. The alkalinity value for all locations exceeds the permissible limits. The highest value of alkalinity is noted at Thirupoondi (south). The hardness of groundwater in the study area ranges from 160 mg/l to 610 mg/l in PRM season and 156 mg/l to 542 mg/l in POM season. Velankanni (570 mg/l) and vepancheri (610 mg/l) places are having the value of above standard limits. The TDS value ranges between 912 to 2028 mg/l during PRM season and 876 to 1984 mg/l in POM season. All tested values are within the permissible limits. Calcium concentration in the study area varies from 50 mg/l to 250 mg/l and 55 mg/l to 220 mg/l in PRM and POM season respectively. The magnesium value lies between 30 to 170 mg/l in PRM season and 26 to 128 mg/l in POM season. The P. R. Puram (170 mg/l) is a higher amount of magnesium compared with standard limits during this study. Sodium concentration in the groundwater samples of the study area varies between in PRM season about 90 to 760 mg/l and in POM season 112 to 742 mg/l. The highest value is shown at velankanni 760 mg/l. The chloridevalue varies between in PRM season 110 to 810 mg/l and in POM 105 mg/l to 596 mg/l, most of the samples exceed the permissible in both seasons. In the study area the sulphates values are range from 200 to 450 mg/l in PRM season and in POM season the values vary 185 to 385 mg/l. All places are within standard limits other than vepancheri (450 mg/l). Nitrate has low concentration varying from 0 to 30 mg/l in PRM season and 0 to 25 mg/l in POM season. Fluoride exists naturally in water sources. The region ranges from 0.3 mg/l to 1.8 mg/l in PRM season and in POM season it varies from 0.1 to 1.2 mg/l. Most of the samples within the standard limits. The highest value of the Study area effect is noted at Velankanni (1.8 mg/l), Karapidagai (1.8 mg/l) and Pudhupalli (1.6 mg/l). Potassium concentration of all-region values between in PRM season is 45 mg/l to 242 mg/l and in POM seasons its ranges between 26 to 167 mg/l. The phosphate values varied between 0 to 5.1 mg/l during PRM season and in POM season it ranges from 0 to 3.1 mg/l. The highest value shows that the karuganni (5.1 mg/l), thirukkuvalai (5 mg/l), meenambanallur (4.5 mg/l). The iron value

ranges between 0.0 mg/l to 3.5 mg/l in both PRM and POM season. The water chemistry analysis showed that the cations order as Na >Ca> K > Mg and anions order as HCO3 >Cl> SO4 > NO4 > PO4 > F in both PRM and POM season (Lacombe *et al.,* 2002).

Table 1: Compare with who standards & statistical analysis

Parameter	WHO STD	Pre-monsoon			Post-monsoon		
		MIN	MAX	% of the samples	MIN	MAX	% of the samples
pH	6.5 – 9.2	6.9	8.8	100%	6.3	8.6	95%
EC	300	356	1371	-	325	1238	-
Alkalinity	120	280	675	-	250	863	-
Hardness	300	160	610	22.5%	156	542	35%
Chloride	200 - 600	110	810	62.5%	105	596	72.5%
TDS	500	912	2028	-	874	1874	-
Ca	75 - 200	50	250	72.5%	55	220	85%
Mg	30 - 150	30	170	65%	26	143	80%
SO_4	200-400	200	450	67.5%	185	395	82.5%
Na	200	90	760	57.5%	112	742	70%
K	32	57	196	-	26	167	35%
NH_3	-	0.3	1.2	55%	0.1	1.5	67.5%
NO_3	45	0.0	30	100%	0.0	45	100%
PO_4	-	0.0	5.1	57.5%	0.0	3.5	75%
Fe		0.0	3.5		0.0	3.5	
F		0.3	1.8		0.1	1.2	

2. Recognization of criteria ratio values of pre-monsoon and post-monsoon for seawater intrusion:

To identify saline water, some hydro geochemical ratios are advised to find, like Ca/mg, Cl/HCO_3 and Na / Cl. Based on that the amount

Table 2: Hydrogeochemical ratios in study area

Location	Pre-monsoon (July 2017)			Post-monsoon (Jan 2018)		
	Na/Cl ratio	Ca/Mg ratio	Cl/Hco3 ratio	Na/Cl ratio	Ca/Mg ratio	Cl/Hco3 ratio
S(1)	1.37	2	0.86	1.29	2.1	0.55
S(2)	2.64	1.43	0.24	2.24	1.26	0.36
S(3)	1.39	1.67	0.53	1.46	1.33	0.62
S(4)	0.38	2.4	5.25	0.33	2.67	2.18
S(5)	1.12	1.1	0.81	0.79	0.91	1.09
S(6)	2.25	1.67	0.35	2.1	1.59	0.27
S(7)	1.21	1.29	0.76	1.01	1.11	0.57
S(8)	0.82	2.17	1.5	0.57	4.33	0.85
S(9)	0.56	6	1.35	0.62	5.43	1.03
S(10)	1.38	0.64	0.94	0.91	42.96	0.79
S(11)	0.88	4.5	1.28	1.05	1.19	0.5
S(12)	0.99	1.19	0.9	1.25	2.5	1.71
S(13)	2.58	2.63	0.68	2.72	5.12	0.65
S(14)	2.64	5	0.71	3.16	1.22	0.43
S(15)	3.61	1.56	0.5	3.97	2.64	0.18
S(16)	2.3	1.14	1.03	2.38	4.88	0.51
S(17)	1.4	4.25	1.07	1.2	1.56	0.57
S(18)	0.72	1.09	1.38	0.7	1.39	0.6
S(19)	0.46	0.71	1	0.39	4.88	0.61
S(20)	0.72	1.08	0.71	0.78	1.01	0.5
S(21)	3.06	1.06	0.56	1.94	0.77	0.57
S(22)	1.64	1.29	1.17	1.72	0.97	0.57
S(23)	1.65	3.6	1	1.75	0.94	0.5
S(24)	1.58	4.67	1.32	1.76	1.59	0.39
S(25)	0.99	2	0.8	1	3.88	0.5
S(26)	1.88	1.27	0.92	2.1	3.84	0.95
S(27)	5.46	1.54	0.38	4.75	2	0.42
S(28)	1.48	1.33	0.96	1.78	1.52	1.05

S(29)	0.99	2.67	1.23	0.97	1.6	0.98
S(30)	1.57	4	1.06	1.53	1	0.75
S(31)	0.96	1.67	1.52	0.9	3.04	0.88
S(32)	1.06	1.58	1.26	1.08	3.62	0.6
S(33)	0.86	2	0.67	0.83	1.69	0.58
S(34)	0.71	4.2	0.77	0.76	1.55	0.66
S(35)	0.83	3.29	1.03	0.82	2.02	0.77
S(36)	0.48	1.33	2.07	0.81	4.35	1.14
S(37)	0.81	0.57	1.84	0.79	3.22	1.08
S(38)	0.73	0.93	1.63	0.74	1.1	1.02
S(39)	0.51	1.25	1.29	0.44	0.71	0.89
S(40)	1.24	2.16	1.11	1.03	1.33	0.68

2.1 Na/Cl ratio:

Na/Cl ratio is generally lower values of seawater intrusion in coastal aquifers when compared to the marine values because molar ratio is <0.86, otherwise Na/Cl ratio is higher values depending upon the sources of anthropogenic characterization (i.e. domestic waters). Thus low values of Na/Cl ratio is not affected in study area for some regions. According to Na/Cl ratio, Thus PRM Season evaluated 5% of samples high contamination and 12.5% of the samples in completely seawater in the study area. Normally groundwater ranges from 45% of the regions having suitable drinking purpose. Thus POM Season evaluated 5% of samples high contamination and normally groundwater ranges from 62.5% of the regions having suitable drinking purpose. 7.5% of the samples low contamination and 25% of the samples moderately contamination in our study area (ICMR, 1975)

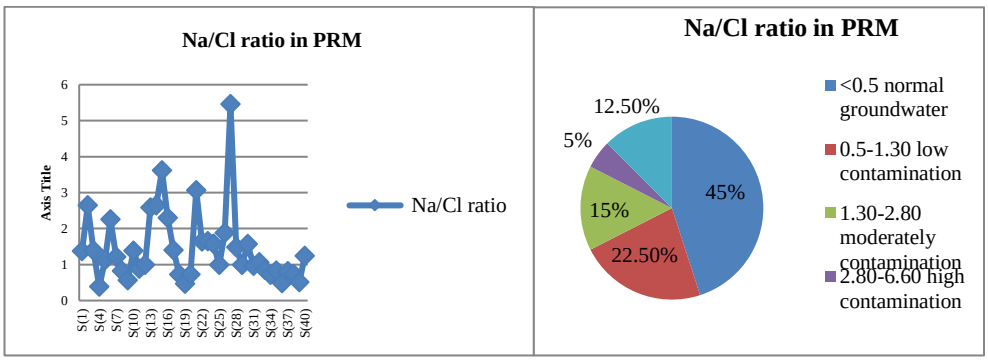

Figure 1: Contamination based on Na/Cl ratio in PRM

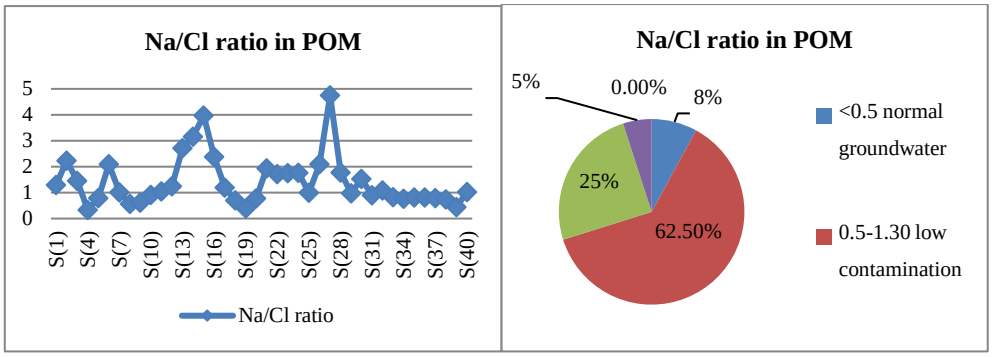

Figure 2: Contamination based on Na/Cl ratio in POM

Table 3: Na/Cl ratio classification

S.NO	Ranges (Na/ Cl ratio)	Description	% of the samples	
			PRM	POM
1.	< 0.5	Normal groundwater	45%	62.5%
2.	0.5 -1.30	Low contamination	22.5%	7.5%
3.	1.30 -2.80	Moderately contamination	15%	25%
4.	2.80 -6.60	High contamination	5%	5%
5.	> 6.60	Seawater	12.5%	-

2.2 Ca/Mg ratio:

Magnesium is a dominant cation and study area all location magnesium values present values higher concentration than calcium because Ca/Mg ratio is contamination of seawater denoted as low. To evaluates seawater contamination to be considered in Ca/Mg ratio parameter. Therefore, According to Ca/Mg ratio, in the study area PRM is 7.5% of samples high contamination and totally seawater is 10% are showing low Ca / Mg ratio (Table 5 and Figure 3&6). Normally groundwater ratio ranges from 20% of the samples.

Table 4: Ca/Mg ratio classification

S.NO	Ranges (Ca/Mg ratio)	Description	% of the samples	
			PRM	POM
1.	< 1.0	Normal groundwater	20%	30%
2.	1.0 -1.5	Low contamination	32.5%	35%
3.	1.5 -2.5	Moderately contamination	30%	20%
4.	2.5 -3.5	High contamination	7.5%	15%
5.	> 3.5	Seawater	10%	-

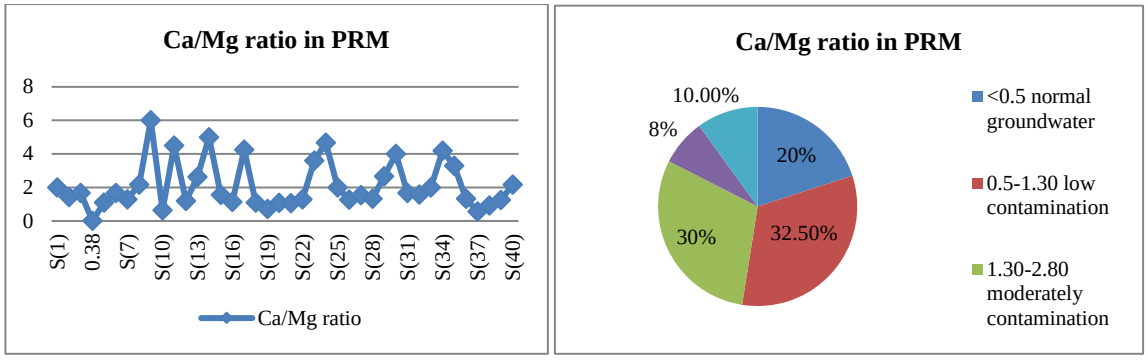

Figure 3: Contamination source based on Ca/Mg ratio in PRM

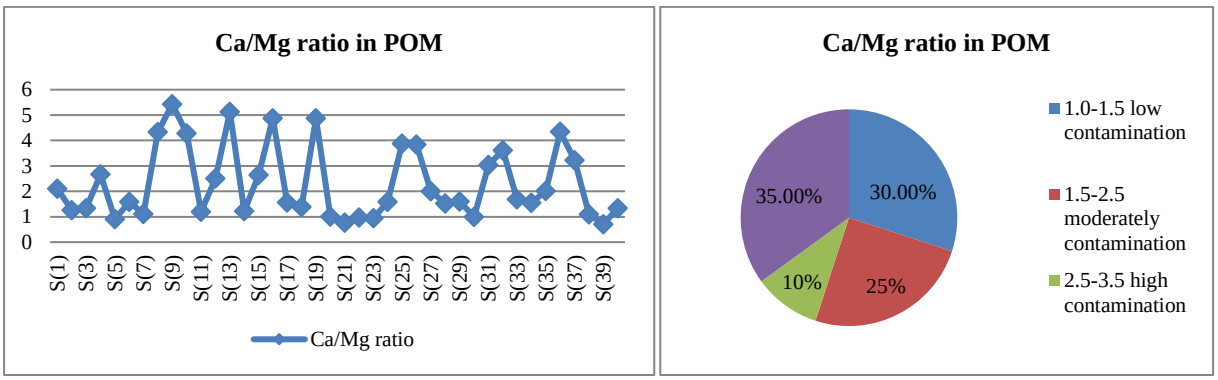

Figure 4: Contamination source based on Ca/Mg ratio POM

Thus post-monsoon in the study area 15% of samples high contamination and seawater not affected in all regions. 30% of the samples are normal groundwater (Mandal and Shiftion, 1981).

2.3 Cl / HCO_3 Ratio:

To evaluates Cl /HCO_3 ratio used as a seawater intrusion. Chlorides are dominant anion of marine water and groundwater chemical parameter of bicarbonate is generally most negative ions, but it occurs in only minor amounts in sea water. The values varied between PRM 45% of the samples freshwater and 80% of the samples POM season. 35% & 15% of the samples low contamination in PRM & POM respectively. Seawater is 2.5% of the samples PRM and POM season not affected in the study area (Carrier, 1958).

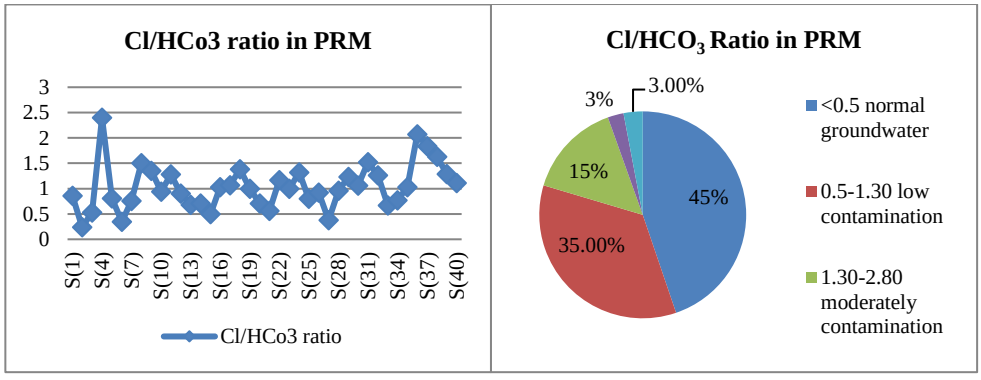

Figure 5: Contamination source based on Cl/Hco$_3$ ratio PRM

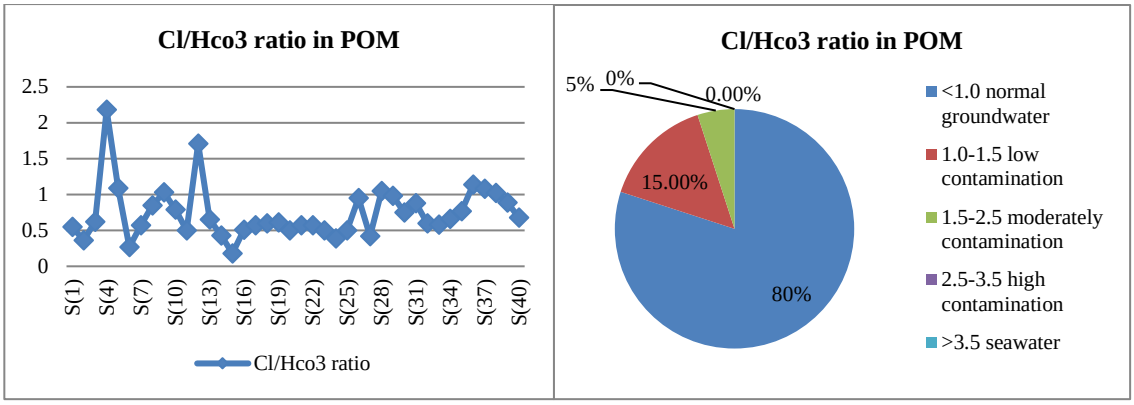

Figure 6: Contamination source based on Cl/Hco$_3$ ratio POM

Table 5: Cl / HCO$_3$ ratio classification

S.NO	Ranges (Cl/ HCO$_3$ ratio)	Description	% of the samples	
			PRM	POM
1.	< 1.0	Normal groundwater	45%	80%
2.	1.0 -1.5	Low contamination	35%	15%
3.	1.5 -2.5	Moderately contamination	15%	5%
4.	2.5 -3.5	High contamination	2.5%	-
5.	> 3.5	Seawater	2.5%	-

2.4. Seawater mixing index

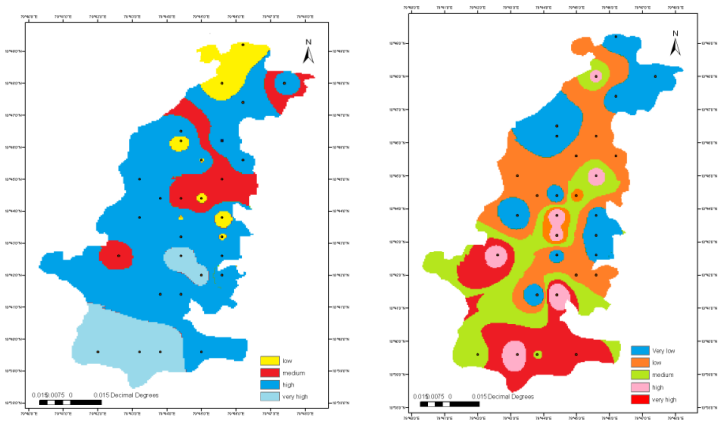

Figure 7: PRM Spatial distribution of SMI Fig 4.10.POM Spatial distribution

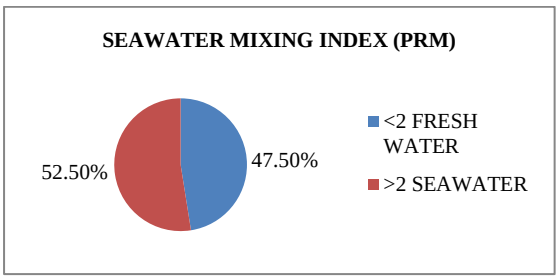

Figure 8: Contamination SMI in PRM

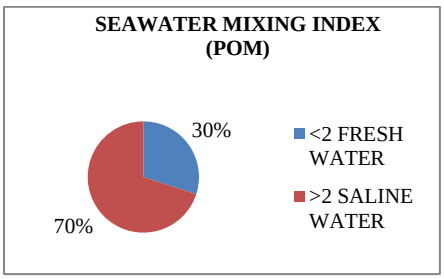

Figure 9: Contamination SMI in POM

Table 6: Seawter mixing index

S. No	Study Area	Pre-Monsoon		Post-Monsoon	
		SMI	Nature of Water	SMI	Nature of Water
1	Thirukkuvalai	1.66	**FRESH**	1.57	**FRESH**
2	Valakarai	1.37	**FRESH**	**1.42**	**FRESH**
3	Meenambanallur	2.1	SALINE	1.87	**FRESH**
4	Madapuram	3.96	SALINE	3.5	SALINE
5	Melapidagai	2.82	SALINE	2.54	SALINE
6	Karuganni	1.46	**FRESH**	**1.23**	**FRESH**
7	Melathannilapadi	2.51	SALINE	2.31	SALINE
8	Thirupoondi(N)	3.73	SALINE	3.45	SALINE
9	Thirupoondi(S)	3.87	SALINE	3.89	SALINE
10	Cholavidyapuram	3.91	SALINE	3.54	SALINE
11	P.R.Puram	4.52	SALINE	4.23	SALINE
12	Vepancheri	4.22	SALINE	4.68	SALINE
13	Palakurichi	2.89	SALINE	1.92	**FRESH**
14	Agalankannu	2.68	SALINE	1.76	**FRESH**
15	Paravai	2.52	SALINE	2.67	SALINE
16	Velankanni	3.51	SALINE	3.24	SALINE
17	Chinathuboor	2.79	SALINE	1..89	**FRESH**
18	Periyathumboor	1.89	**FRESH**	**1.75**	**FRESH**
19	Erayankudi	1.71	**FRESH**	**1.78**	**FRESH**
20	Needur	1.86	**FRESH**	**1.56**	**FRESH**
21	Sembiyamahadevi	1.63	**FRESH**	**1.69**	**FRESH**
22	Aayamalai	2.62	SALINE	1.92	**FRESH**
23	Agaram	3.1	SALINE	3.23	SALINE
24	Thalayamalai	1.84	**FRESH**	**1.23**	**FRESH**
25	Thannilapadi	2.72	SALINE	2.34	SALINE
26	Venmanacheri	3.28	SALINE	3.76	SALINE
27	Vizhunthamavadi	1.56	**FRESH**	**1.78**	**FRESH**
28	Karapidagai(N)	3.9	SALINE	1.97	**FRESH**

29	Karapidagai(S)	1.74	**FRESH**	**1.43**	**FRESH**
30	Ettukudi	3.25	SALINE	1.63	**FRESH**
31	Seeravattam	3.32	SALINE	2.34	SALINE
32	Ottathattai	3.67	SALINE	3.57	SALINE
33	Prathamapuram	3.87	SALINE	3.83	SALINE
34	Thiruvaymoor	4.23	SALINE	3.98	SALINE
35	Vallam	4.45	SALINE	4.76	SALINE
36	Keelaiyur	2.79	SALINE	2.54	SALINE
37	Esanur	1.93	**FRESH**	**1.67**	**FRESH**
38	Alangudi	2.45	SALINE	1.96	**FRESH**
39	Pudhupalli	1.48	**FRESH**	**1.56**	**FRESH**
40	Vettaikaraniruppu	3.23	SALINE	3.12	SALINE

Seawater mixing index of Pre-monsoon classified of 30% of the samples freshwater in the study area and finally analysed results for maximum 70% of the samples contaminated with groundwater that is saline water of coastal area regions are identified. Seawater mixing index of Post-monsoon classified of 47.5% of the samples freshwater in the study area and finally analysed results for maximum 52.5% of the samples contaminated with groundwater that is saline water of coastal area regions are identified. This post-monsoon better than the pre-monsoon season of seawater intrusion and groundwater quality (WHO, 1971).

WATCLAST analysis

The WATCLAST program is used to analyze the water sample in 14 category and its values represent the results in four types of graphs. Like USSL Diagram, Doneen plots for permeability index, Gibbs diagram and Johnson plot. The sodium % is estimated by Wilcox method and Eaton method. It shows that 55% of ground water samples were in permissible limit and safe condition and remaining sample were in doubtful and unsafe condition in both seasons. The SAR value of 90 % samples is in excellent category and others in good category and RSC values of samples were in good category. The Electrical conductivity by Wilcox method gives the ground water samples have permissible value in this both season. The USGS method of hardness shows all the sample of POM and PRM season are very hard. Based on IBE Schoeller 95 % water samples are (Na +K) rock ->Ca/Mg groundwater category and remaining were in (Na +K) ground water ->Ca/Mg rock

category. The Schoellerclassified the 72.5 % ground water as type I category and other samples were in type II and type III category. The corrositivity ratio of the lake water shows all the samples were in safe category. The chloride classification of the water samples shows 7.5 % samples in fresh Category, 30 % samples in fresh brackish Category and 62.5 % samples in brackish Category in all the seasons. The 95% Ground water samples of both season are in Ca – Na cationfaciesand anion facies of sample shows 75 % in Cl – So_4 – HCO_3faciesand remaining are in Clfacies. The hardness classification showed that all the samples in permanent hardness classification. The WATCLAST results for both POM and PRM season is presented in table (Achari *et al.,* 2005; Rao and Rao, 1988).

The USSL classification for irrigation water shows that most of the groundwater samples were laid in the C2S1 and C3S1 category in POM season and in PRM season 50% of water samples in C2S1 category and remaining samples in C2S2 category. This is mainly due to contamination of seawater to the groundwater. As per the classification of hydro geochemical facies the groundwater samples were classified as underwater contamination with gypsum in both POM and PRM season. The Gibbs Boomerang diagram shows that the groundwater is highly influenced by evaporation in both POM and PRM season (Pavithra *et al.,* 2016).

Conclusion:

Groundwater samples from P. R. Puram, velankanni, karuganni, karapidagai, keelaiyur, madapuram, valakarai region shows seawater intrusion because of its TDS, Chloride, electrical conductivity, ammonia, calcium, magnesium, sulphate, Hardness in these areas also marked highest. Due to the increase in the population the demand for water has increased nowadays. In our study area many regions affected by Iron (or) Fe concentration. Phosphate is higher in the sample collected from thirukkuvalai, meenambanallur, karunganni region. There are affected areas not suitable for drinking purpose so groundwater management having not perfectly some regions in the nagapattinam district. To delineated seawater intrusion Na/Cl ratio ranges from 45% of the water sources to be normally suitable of groundwater remaining contamination of water in the study area, Ca/Mg ratio values varied from 20% of the water sources for only used in the drinking purpose and Cl/Hco3 ratio ranges from 45% of the regions is suitable for drinking water standard otherwise regions in the study area not suitable because contamination of groundwater. Spatial distribution of SMI shows that the classified classes in contaminated with groundwater.

Category	Grade	POM	PRM	Category	Grade	POM	PRM
EC Wilcox (1955)				**S.A.R. Richards (1954)**			
Excellent	<250	1	0	Excellent	0-10	36	35
Good	>250-750	13	22	Good	10-18	4	5
Permissible	750-2000	26	18	Fair	18-26	0	0
Doubtful	2000-3000	0	0	Poor	>26	0	0
Unsuitable	>3000	0	0	**R.S.C Richards (1954)**			
TDS Classification (USSL, 1954)				Good	<1.25	40	39
Fresh Water	<200	0	0	Medium	1.25-2.5	0	1
Brackish Water	200 – 500	0	0	Bad	>2.5	0	0
Saline Water	500 – 1500	27	32	**Hardness Classification (Handa , 1964)**			
Brine Water	1500 - 3000	13	8	**Permanent Hardness**			
Chloride Classification (stuyfzand , 1989)				A1		0	0
Extremely Fresh	<0.14	0	0	A2		7	7
Very Fresh	0.14-0.84	0	0	A3		33	28
Fresh	0.84-4	3	3	**Temporary Hardness**			
Fresh Brackish	4.23-8.46	12	17	B1		0	0
Brackish	8.46-28.21	25	20	B2		0	0

Brackish Salt	28.21-282.1	0	0	B3		0	4
Salt	282.1-564.1	0	0	**Corrosivity Ratio (1990)**			
Hyperhaline	>564.3	0	0	Safe	< 1	40	39
Na% Wilcox (1955)				Unsafe	>1	0	1
Excellent	0-20	0	0	**USGS hardness**			
Good	20-40	0	2	Soft	< 75	0	0
Permissible	40-60	22	17	Slightly hard	75- 150	0	0
Doubtful	60-80	18	20	Moderately hard	150-300	0	1
unsuitable	>80	0	1	Very hard	>300	40	39
CationFacies				**IBE schoeller (1965)**			
Ca- Mg Facies		0	0	(Na + k) rock >Ca/ Mg g.w		38	37
Ca- Na Facies		38	38	(Na + k) g.w>Ca/ Mg rock		2	3
Na – CaFacies		2	2	**Schoeller classification**			
Na Facies		0	0	TYPE I		29	32
Anion Facies				TYPEII		6	4
HCO3 Facies		0	0	TYPE III		5	4
HCO3 - CL-SO4 Facies		0	0	TYPE IV		0	0
CL- SO4 - HCO3 Facies		30	35				
CL - Facies		10	5				

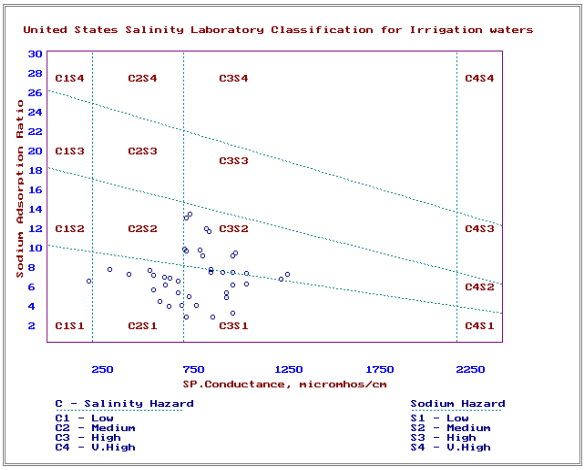

Figure 10: USSL classification for water in PRM season

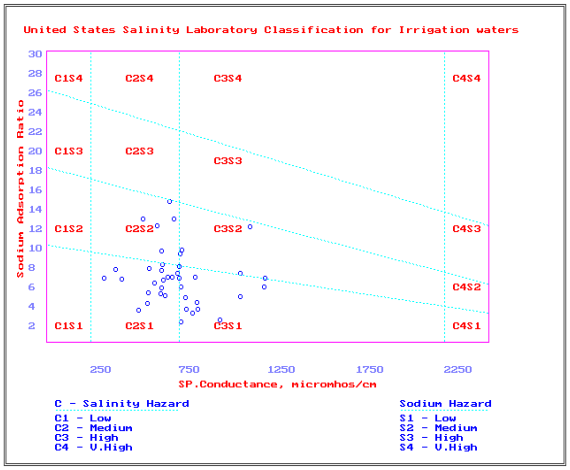

Figure 11: USSL classification for irrigation water in POM season

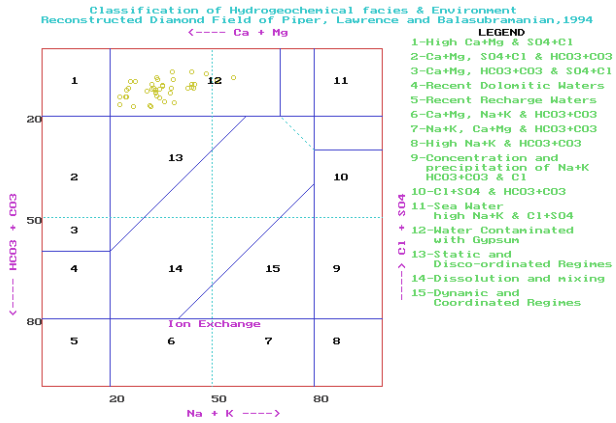

Figure 12: Classification of hydro geochemical facies in POM season

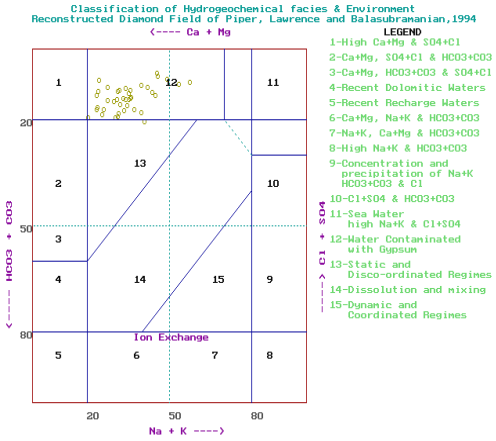

Figure 13: Classification of hydro geochemical facies in PRM season

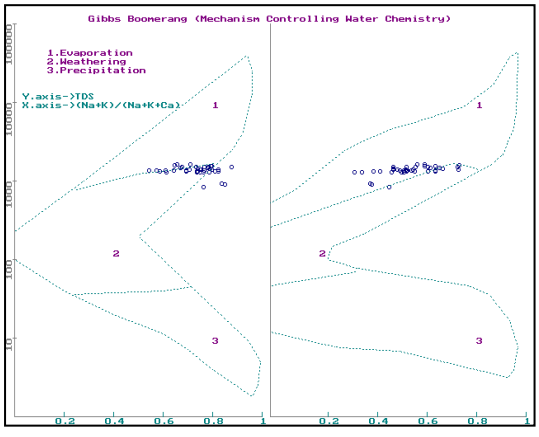

Figure 14: Gibbs Boomerang diagram in in POM season

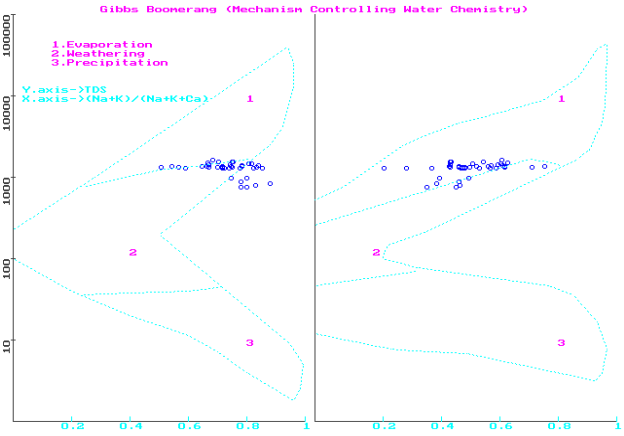

Figure 15: Gibbs Boomerang diagram in in PRM season

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STUDY OF CLIMATE CHANGE IMPACTS ON GROUNDWATER FLUCTUATIONS IN THANJAVUR DISTRICT, TAMILNADU, INDIA

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Abstract:

Climate change is the variation of weather pattern among their environmental conditions occurs a particular specified period all over the world. This study covers the groundwater fluctuation with various climatological factors for the Thanjavur district Tamil Nādu. The climatological data like daily rainfall, daily temperature and Groundwater level were collected from statistical data center Tharamani, Chennai for 20 years (1999 - 2018). The El – Nino and LA – Nina occurrence were collected from National Oceanic and Atmospheric Administration (NOAA) center. Based on the collected data the runoff is estimated by using Indian Council for Agricultural Research (ICAR) method. The evapotranspiration (ET) is calculated from Blaney – Criddle Equation. From this evaluation the atmospheric temperature is increased in recent years this mainly due to change in El – Nino and LA – Nina occurrence pattern. The study area receives 50 % of rainfall during North East monsoon season and highest annual average rainfall noted in Papanasam Taluk. The highest runoff is estimated in November month because of low atmospheric temperature and high soil moisture content. The ET value increased in recent years mainly reduction in land cover and urbanization. The highest groundwater fluctuation occurs during 2013 to 2015 is mainly due to increasing in Oceanic Nino Index value (ONI). The future Groundwater Fluctuation is identified based on ONI value is predicated by statistical analysis.

Keywords: El – Nino, Rainfall Pattern Change, Temperature Rise, Groundwater table Fluctuation GIS

Introduction:

Climatic change due to the boosted greenhouse effect is likely to have substantial effect on hydrological cycle, which plays an important role in both surface and subsurface

water balance study. The projected global change includes groundwater systems, which are linked with changes in climate over space and time. Consequently, the global change affects key aspects of subsurface hydrology (including soil water, deeper vadose zone water, and unconfined and confined aquifer waters. Research and publications addressing projected climate effects on subsurface water are catching up with surface water studies. Groundwater has been depleted in many regions, but the management of subsurface storage remains an important option to meet the combined demands of agriculture, industry (particularly the energy sector), municipal and domestic water supply, and eco systems. Increasing evidence of changing climatic pattern is being observed and the impact of this change on ground water has a direct impact on the livelihood and economy of the region. Considering that the impact of climate changes on ground water resources, monitoring the status of their resources and maintaining their sustainability under the influence of these changes is of great importance. Water may be got by surface water or groundwater. But in groundwater, the level may be varied due to climatic change that has affected the normal hydro geological cycle by manmade activities too. Majorly some meteorological parameter-influenced impacts on groundwater level are rainfall, temperature, evapo-transpiration, precipitation, infiltration (Senthil Kumar and Elango, 2002).

Then, we collect the climatic data for the selected site area from the weather station over a decade and comparing the corresponding data with groundwater level and analysis through the hydrological model to give a solution for future concerns. The spatial and temporal variation in the magnitude and intensity of temperature and rainfall over different regions of the world has been observed as a result of climatic change (3). The other parameter's like evapo- transportation, run off and EL – NINO and LANINA are considered in this study-on-study area. For evaluating the ground water Fluctuation. Thanjavur district is a semi – arid region which is selected for this study. It's also called as Rice bowl of Tamil Nādu. The major water resource of this district is Cauvery River, which form's a delta region highly. So, the production of crop was higher. Now day's the flow of water in the river reduced, due to river water sharing between the states and climatic change. Because of this reason the ground water is becomes necessary for domestic and irrigation purpose (Kumar and Ahmed, 2003).

The study's objectives

The objective for this study area is to formulate some adaptation strategies to give a solution or various ways for reducing the vulnerability of groundwater level due to climate change impact, that create the severe drought, flooding and create landslides problems to overcome those problems. Then, here to assess the climatic change that will create enormous environmental impacts to understanding such impact employing analyzing the meteorological data for selected location over a specified period. And also to suggest the suitable remedial measure for those impacts before it occurs to maintain the groundwater level by constructing of ponds to recharge it is exceeded for preventing than negative impact before it occurrences (Vennila, 2007).

Data and Methodology

Study area

Thanjavur district is a semi-arid region that is selected for this study. The river Cauvery flows seasonally over the district. Hence rainwater conservation becomes necessary to overcome the demand of agricultural and other needs. The location of Thanjavur offers detailed information about the exact position of an ancient city. It is situated on the eastern coast of the state of Tamil Nadu in south India. It is bounded by the Thiruvarur district on the east, by sea (Gulf of manner) one the southeast, by Pudukkottai distraction the south and southwest, by Tiruchirappalli district on the west and northwest and by Ariyalur district on the northeast. Geographically it is placed between latitude 9 50’ and 11 25’N, longitude78 45’, 70 25’E, and spread area is 3396.57 km. The study area map as shown in figure 1 (Sharma, 2005).

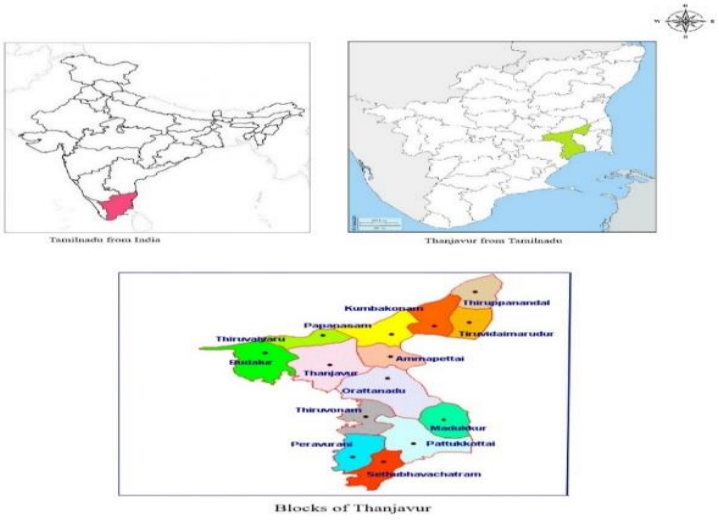

Figure 1: Study area map

Thanjavur experiences a tropical climate with no major change in temperature between summer and winter. Rainfall is highest between October and December because of the north-east monsoon winds, and from December to February, the climate is cool and moist. The location map of the study area is shown in figure 1 (Rathod and Aruchamy, 2010).

Methodology

The rainfall temperature and groundwater were initially analyses monthly, annually, and seasonally in this study. Based on rainfall, runoff, and ET, the change in storage is calculated using the ICAR (Indian Council for Agriculture Research) technique, and ET is calculated using the Blaney – Criddle method. The occurrence patterns of EL-NINO and LA-NINA are then compared to rainfall, temperature, runoff, and storage changes. The impact of climate change on meteorological and hydrological parameters has been established as a result of this (Bates *et al.,* 2008)

Data and Sources

The data used for this study area are,

1. Meteorological data: Rainfall, Temperature, EL - Nino and LA - Nino
2. Hydrological data: Ground water level, Runoff, Evapo-transpiration

The data are collected from statistical data center, Tharamani, Chennai and, also some data are collected through SWAT global database for this study area taken (Bouraoui *et al.,* 1999).

Rainfall data

Rainfall is the main parameter it will serve a predominant role in agriculture in that area. The rainfall value was analyzed for the four seasons such as the Pre-monsoon, Southwest monsoon, and the Northeast monsoon. Rainfall data were collected over 20 years (1999-2018) for the Thanjavur district (Brouyere *et al.,* 2004).

Then we calculated the average annual rainfall data for the corresponding particular 16 rain gauge station in Thanjavur. First, we find out,

i) Average annual rainfall data for (1999-2018) In four seasons}

=Jan (1999-2018) + Feb (1999- 2018) + Mar (1999-2018) +……+ Dec (1999-2018)

ii) Average monthly rainfall data for (1999-2018)=Jan(1999+2000+2001+……2018) + Feb (1999+2000+……..+2018) +……

iii) Average daily rainfall data for corresponding month over (1999-2018)

= {Jan (1+2+3+4+……+31) in 1999} +……

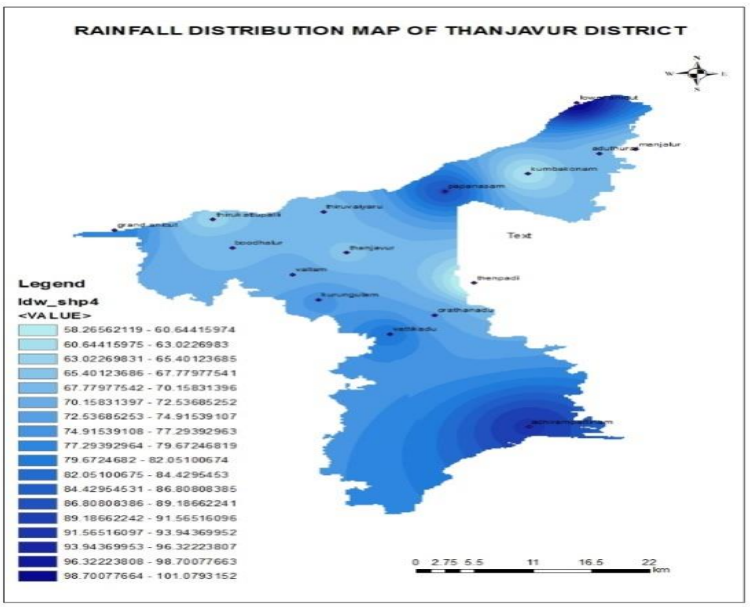

Figure 2: Rainfall Distribution map

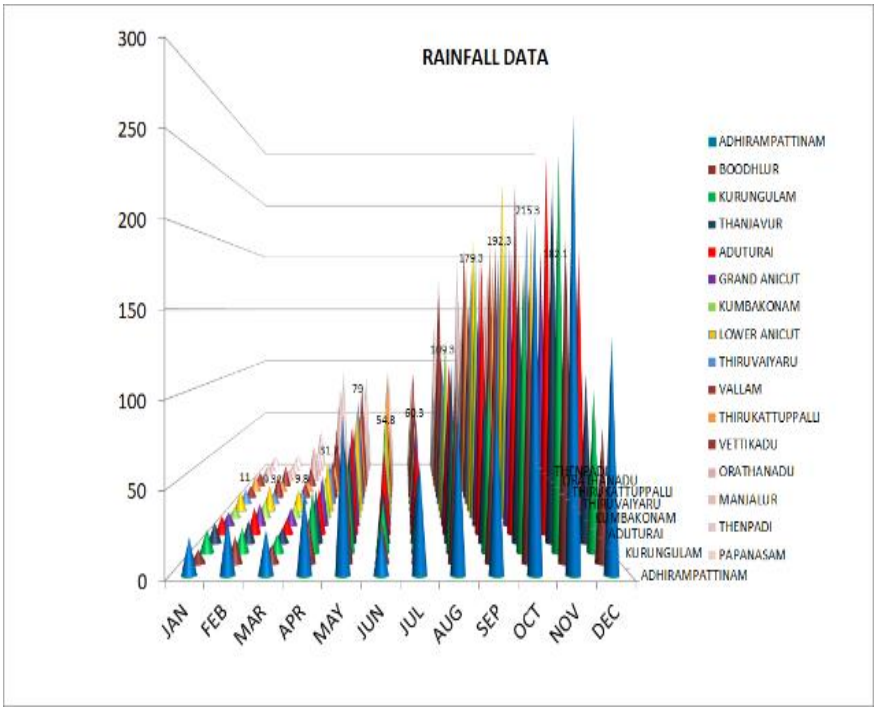

Figure 3: Monthly rainfall Vs Locations

The figure 2 shows the rainfall distribution map of 16 rain gauge stations in Thanjavur district. In this graph, it represents those stations that have an average annual rainfall value as more in 101.3mm and 87.2mm in lower Anicut and Papanasam area station respectively, and the lowest value of rainfall is noted in then Padi as 56.1 mm. Here, the rainfall value was increased from September to December, and then it gradually decreases its rainfall value from March to June. The value of rainfall varies from 10 mm to

70 mm in January to December in the year 1999 to 2018. This clearly shows that the rainfall value is moderate in the year 1999 to 2018 in the month between January to March and June to September. The Average monthly rain of the each station has been plotted in figure 3 (Jyrkama *et al.,* 2007).

Temperature data

The temperature act as a major role in climate change it will create a lot of changes among other parameters, after a statistical analysis of the temperature data obtained from the eight weather area stations shows the annual average temperatures.

The Figure 4 and 5 shows the temperature variation of corresponding stations is Vettikadu, Kurungulam, Boodhalur, Thanjavur area stations in Thanjavur district is taken as the study area. In this graph, it represents those stations has average annual temperature value as 27.92oc, 34.16oc, 27.85oc, 27.71oc. Here, the temperature increases from April to August then it gradually decreases its temperature value from September to December.

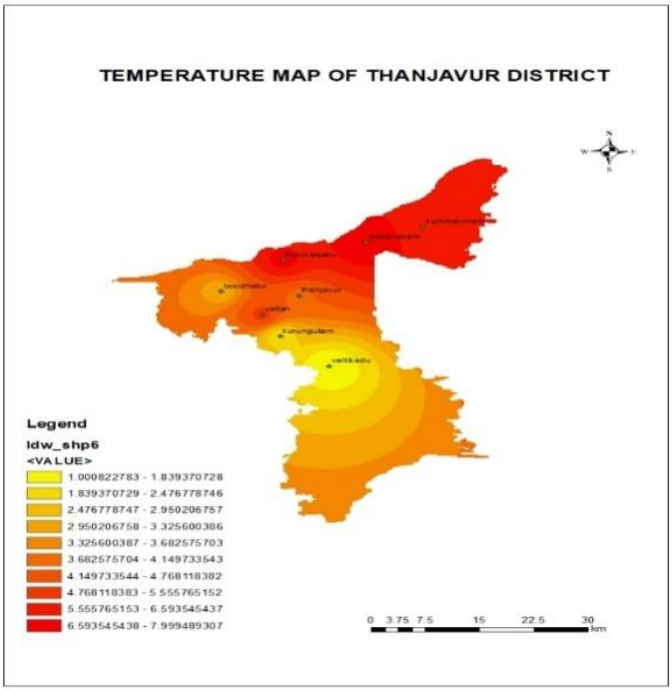

Figure 4: Temperature distribution map

The temperature value is high in July as a value of 38.7oc in Thanjavur area station in the year of 2000 to 2007, 2013.and also the temperature value is low in November in Thanjavur area station as a value of 14.3oc in the year of 2002 to 2014. The value of temperature varies from 13.11oc to 40.56oc in January to December in the year 1999 to

2018. The value of temperature varies from 12.11oc to 40.58oc in January to December in the year 1999 to 2018.

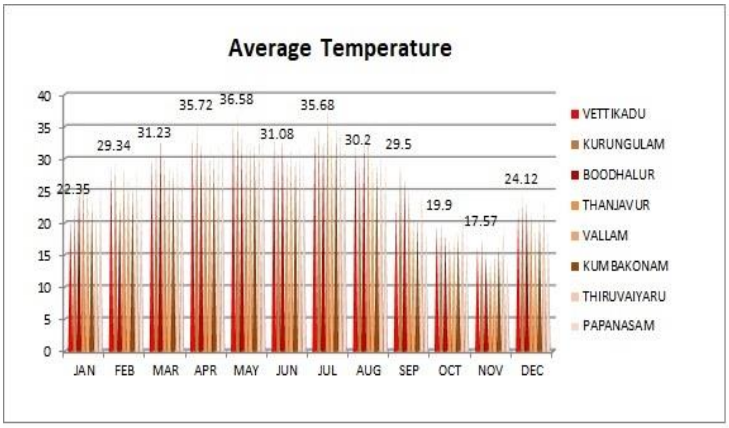

Figure 5: Average Temperature

This clearly shows that the temperature is moderate in the year 1999 to 2018 in the month between the January to March and June to September (Kirshen, 2002).

EL - NINO and LA - NINO Effect

El Niño, too affects atmospheric pressure and temperature, rainfall, and ocean temperature. La Niña's impacts are opposite those of El Niño. Depending on which cycle occurs (and when), it can mean either droughts or flooding. Typically, El Niño and its warm waters are associated with drought, while La Niño is linked to increased flooding. The effect of El - Nino and La - Nino for Tamilnadu is shown in a table1 in weeks, it occurs over a year.

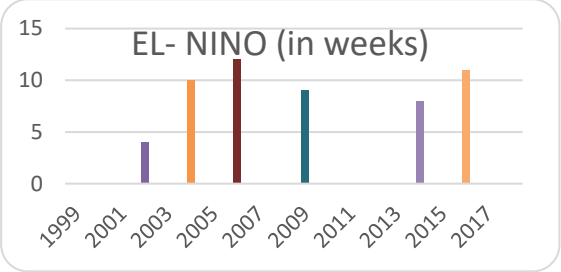

Figure 6: El – Nino Occurrence Vs Year

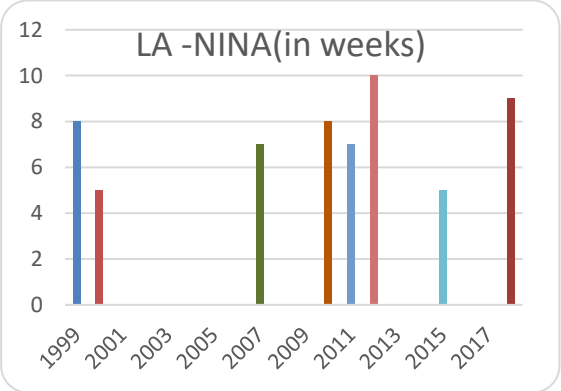

Figure 7: LA – Nina Occurrence Vs Year

Here this study area the effect of El Niño and La Niño can be analyzed based on the sea surface temperature here it shows how long it would occur in a particular year is taken. The figure 6 represents the El Niño effect of this study area as shows the nil value in the starting of 1999 and occurs several weeks in the years of 2002,2004,2006,2009,2014and 2016. It creates a major effect in the year of 2006 for 12weeks in this Thanjavur district (Kumar and Singh 2011).

Table 1: EL – NINO and LA – NINA Occurrence in week

Year	**El Nino**	**La Nino**	**Neutral**
	(in weeks)		
1999	NIL	8	NIL
2000	NIL	5	NIL
2001	NIL	NIL	7
2002	4	NIL	NIL
2003	NIL	NIL	6
2004	10	NIL	NIL
2005	NIL	NIL	5
2006	12	NIL	NIL
2007	NIL	7	NIL
2008	NIL	NIL	7
2009	9	NIL	NIL
2010	NIL	8	NIL
2011	NIL	7	NIL
2012	NIL	10	NIL
2013	NIL	NIL	8
2014	8	NIL	5
2015	NIL	5	NIL
2016	11	NIL	NIL
2017	NIL	NIL	NIL
2018	NIL	9	NIL

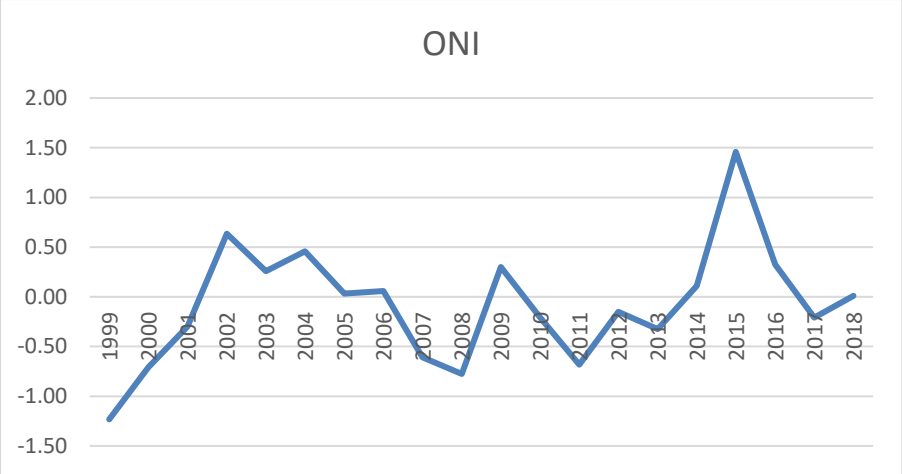

Figure 8: Oceanic Nino Index

The Figure 7 represents the La Niño effect of this study area as shows the nil value at the starting of 2001 and occurs several weeks in the years of 2003, 2005, 2008,2013 ,2014 and 2018.It creates a major effect in the year of 2012 for 10 weeks in this Thanjavur district. And here it clearly shows the El Niño severely occurs in 2006 for 12 weeks. More or less La Niño also occurs more this period more in 2012 for 10 weeks. Neutral also occurs moderate level during 1999-2018 compared to these two effects (Kumar and Singh, 2012).

Ground water level data

The groundwater level data were collected from the corresponding site area in Thanjavur district and also it was analyzed for four seasons like MONSOON, POMKH, POMRB, and PREMON over 20 years. These calculated values are shown in given below table 2.

As the study area is a hard rock terrain, it is observed that some of the places have deeper water levels during the pre-monsoon season. Groundwater starts to replenish the shallow aquifers during the SW monsoon season and reaches high during the NE monsoon period when plants are dormant and evaporation rates are less. The groundwater levels remain stable for the entire season and in a few locations there is a variation of levels due to rainfall variation during the pre-monsoon season. It is observed that by January the water level starts lowering and by May, the water level declined to 2 m in the Ayyampet site area (Natural Resources, 5-7 February 2012).

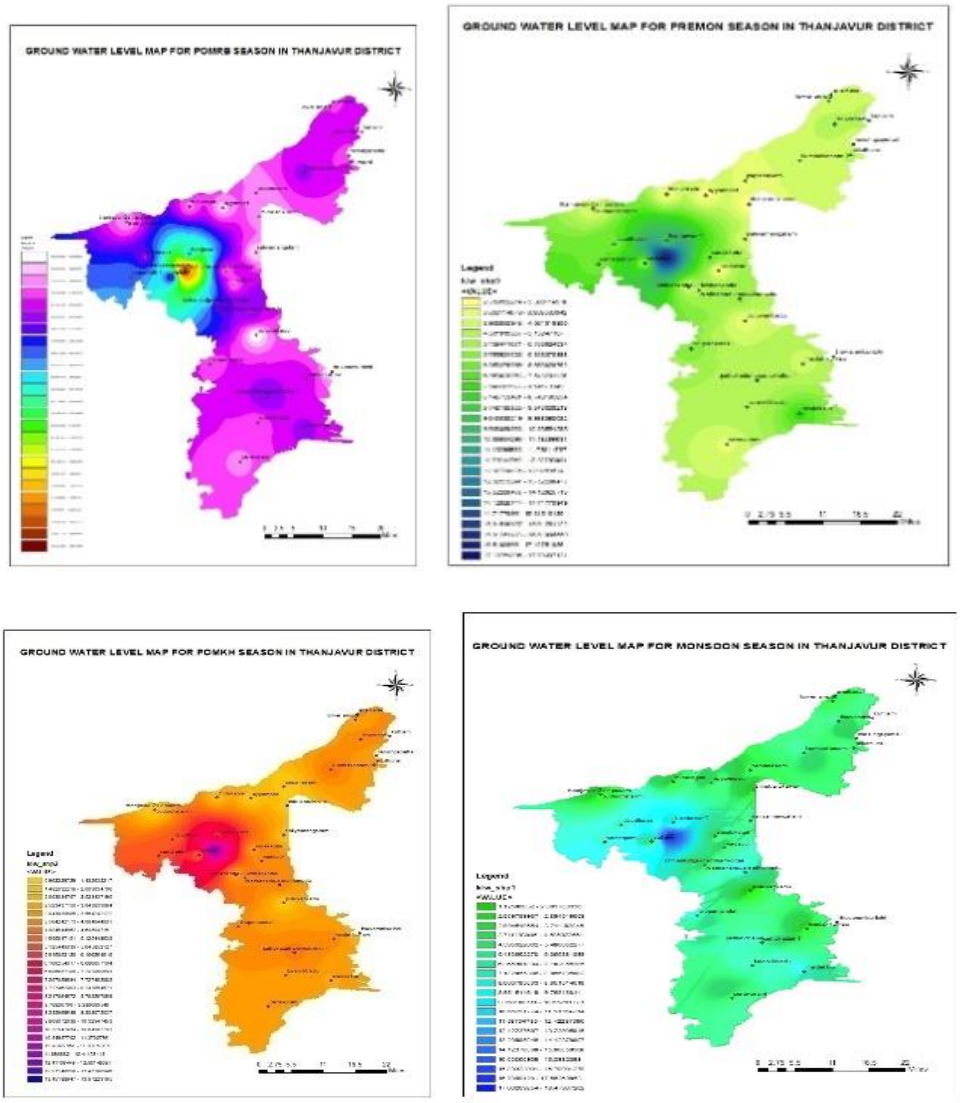

Figure 9: Groundwater level for four seasons

Although there is a substantial amount of rainfall in the south-eastern region where the water level is near-surface conditions during June, the average depth to water level also deepens by December.

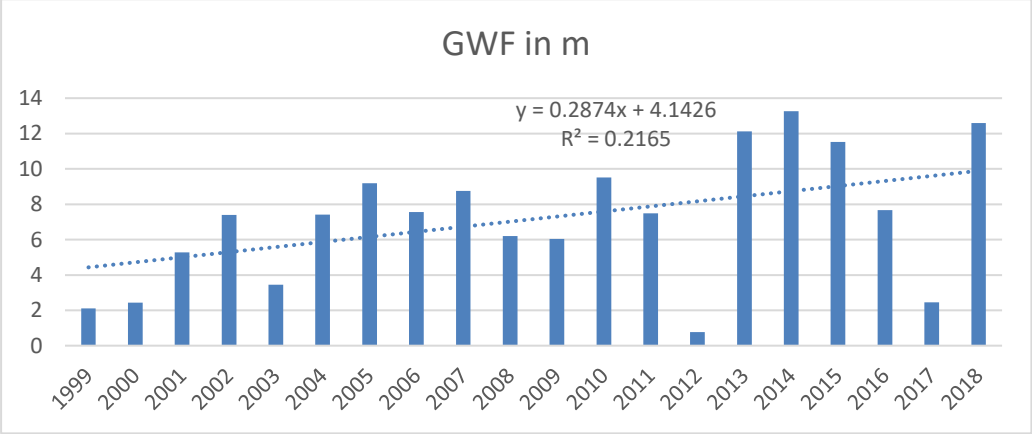

Figure 20: Groundwater fluctuation (1999 - 2018)

This may be due to the hard rock terrain in the region which does not allow water to infiltrate into the deeper aquifer zones, and hence most of the water escapes as runoff and partially gets absorbed into the ground to sustain shallow aquifers. (Rupa Kumar, K. 2005),

Table 2: Ground water level data for thanjavur district

S. No	Site Area	Seasons				Total
		Monsoon	Pomkh	Pomrb	Premon	
1	Aduthurai	4.55	2.55	2.66	4.68	14.6
2	Anaikarai	3.17	2.3	3.49	3.93	3.22
3	Ayyampet	2.55	1.03	0.97	2.99	1.89
4	Ichhankottai	4.03	4.62	5.90	4.91	4.86
5	Ichhankotai-1	3.74	3.43	3.29	4.943	3.85
6	Ichhankotai-Ew	5.12	6.37	2.33	4.11	4.48
7	Kumbokonam-1	5.22	3.21	3.96	4.56	4.24
8	Kuttlam	4.36	3.03	3.62	4.86	3.97
9	Vadavur	3.661	1.62	3.15	2.76	2.80
10	Lower Anaicut	3.149	2.47	2.10	4.215	11.94
11	M.V.Chavadi-E	15.96	8.96	10.9	18.21	54.05
12	M.V.Chavadi-W	18.78	14.4	14.3	14.41	62.00
13	Madakkur	7.699	3.18	2.42	7.746	21.05
14	Madakkur-Ew	2.3	2.72	3.21	4.32	12.55
15	Melvastracavd	16.69	14.3	11.8	16.83	59.69
16	Narsingapettai	3.78	1.92	2.54	3.889	12.13
17	Orathanadu	5.94	1.79	2.30	5.11	15.15
18	Orathanadu-A	8.40	4.55	4.32	5.64	22.91
19	Turaivikkadu	5.66	1.94	2.76	5.08	15.45
20	Papanasam	3.050	1.50	0.96	3.715	9.239
21	Pattukottai-A	5.8	4.56	4.72	5.32	20.4
22	Pattukottai-1	5.635	2.37	2.78	4.463	15.25
23	Peravurani	4.491	1.71	2.88	3.817	12.90
24	Puduchataram	1.980	1.62	1.38	4.098	9.07
25	S.R.Puram	4.642	1.07	1.41	2.277	9.41
26	Saliyamanglam	5.078	0.80	1.58	4.14	11.60
27	Vallam	4.937	3.91	4.22	5.18	18.26

28	Sanarpatti-1	7.141	5.04	4.92	6.37	23.48
29	Surakkotai	4.220	1.69	2.62	6.77	15.31
30	T.Budalur	6.625	3.40	4.55	6.55	21.14
31	Thanjavur-1	8.213	5.89	5.49	9.23	28.84
32	Thanjavur-2	2.087	1.29	0.64	3.85	7.87
33	Tirukarukuvur	2.09	.323	1.08	2.76	7.26
34	Thiruvaiyaru	2.69	1.70	1.62	3.18	9.20
35	Thuvarankurhi	4.29	0.98	1.80	4.60	11.68
36	Tiruvonam	5.07	2.97	3.54	5.12	16.7
37	Tirupanandal	6.63	2.20	3.21	6.15	18.20

However, during December, the eastern and the western part of the state receive higher rainfall with increasing groundwater level at Melavastrachavdi of value as 59.63 m. The groundwater distribution map for the four seasons as shown in fig 9. (Sathaye *et al.*, 2006; Shah, 2009).

Runoff data

Runoff is estimated through various methods, here we used a common method to estimate by using ICAR (Indian Agricultural Research Council) method for estimating annual runoff of small watershed is provided formula as follows,

$$R = \frac{1.15 \times P^{\frac{1}{44}}}{T^{1.34} \times A^{0.0613}}$$

Where, R is Annual rainfall height in (cm); T is Mean annual temperature (o c)

P is Mean annual rainfall in (cm); A is Area, sq. m

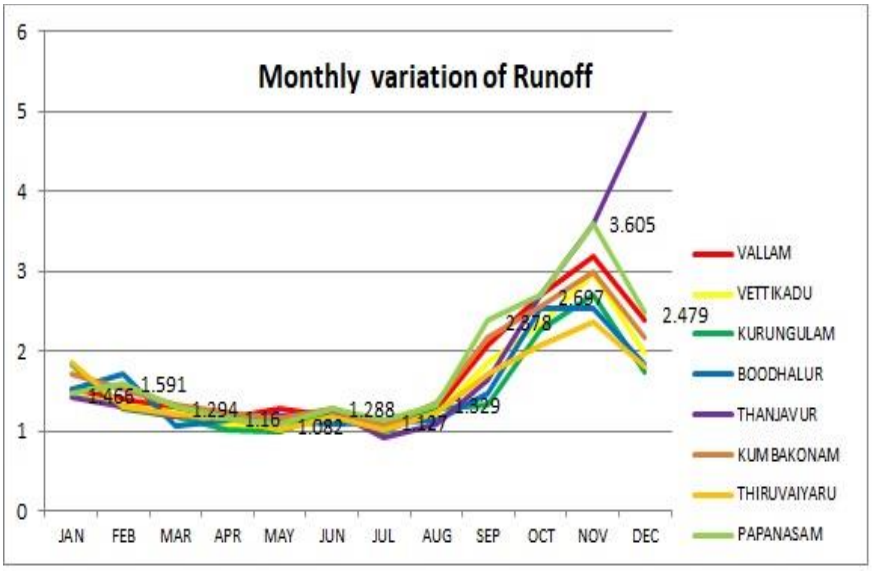

Figure 11: Monthly Variation of Runoff

The result obtained from the runoff estimation in Thanjavur district the highest value is more in Thanjavur with the value of *1.867cm* and the low value of runoff got from Kurungulam with *1.490cm* over the year of 1999-2018 from the above table. And also, the infiltrating water is going to a catch basin or stored in a shallow aquifer, only a few amounts of water will reach the groundwater table based on the soil conditions in that area. The figure 11 & 12 shows the monthly variation of runoff and distribution runoff in the study area (Scibek and Allen, 2006).

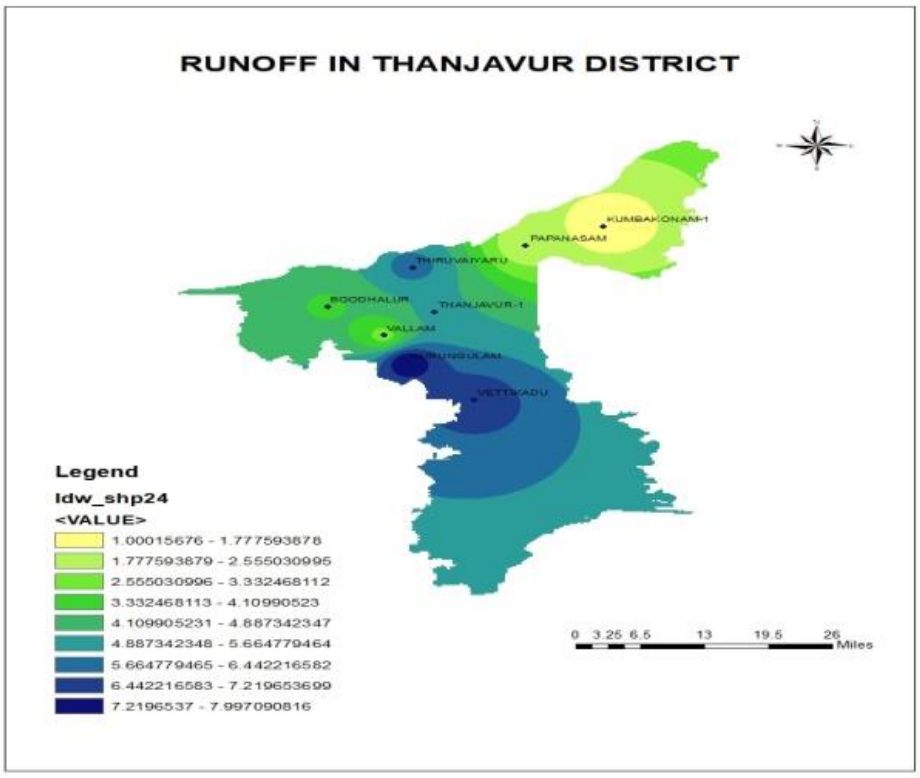

Figure 12: Runoff Distribution map

In the runoff value estimated from the Thanjavur station, it will get the peak value in December among other stations under monthly variation and in the average annual variation of runoff value also. The second most peak value is attained in the kurungulam district also in November to December; the remaining site station also varies from the runoff value on its rainfall value occurring on that area respectively (Shah, 2009).

Evapotranspiration

The calculated the loss of groundwater from the evapo-transpiration by the formula. The Blaney Criddle equation is a relatively simplistic method for calculating evapo-transpiration. However, the Blaney–Criddle equation is ideal when only air-temperature datasets are available for a site, Given the close accuracy of the Blaney–Criddle equation, it

is recommended that it be used to calculate evapo-transpiration for periods of one month or greater.

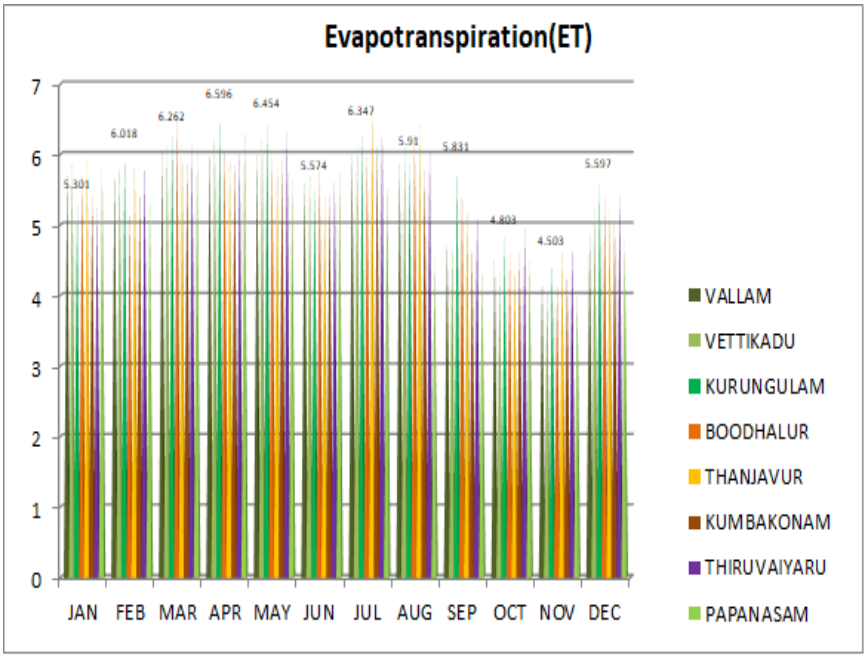

Figure 13: Monthly Variations of Evapo Transpiration

$$ET_0 = P \times (0.457T_{mean} + 8.128)$$

Where

ETo is the reference evapo-transpiration (mm day-1), month,

P is the mean daily time hours.

T_{mean} is the mean daily temperature [°C] given as

$$T_{mean} = (T_{max} + T_{min})/2$$

The figure 13 clearly shows the monthly variations of evapo-transpiration are estimated from the value of annual daily hours 'p' taken from the given table and its corresponding temperature in those eight-station in a Thanjavur district.

In the value of evapo-transpiration estimated from the Kurungulam station, it will get the peak value in April among other stations under monthly variations and in the average annual variation of runoff value also high in that month over 20 years in Thanjavur district.

The second most peak value is attained in the Thiruvaiyaru district also in April to July; the remaining site station also varies from its temperature value occurring on that area respectively. The average ET distribution of study area as shown in figure 14 (Sherif *et al.,* 1999).

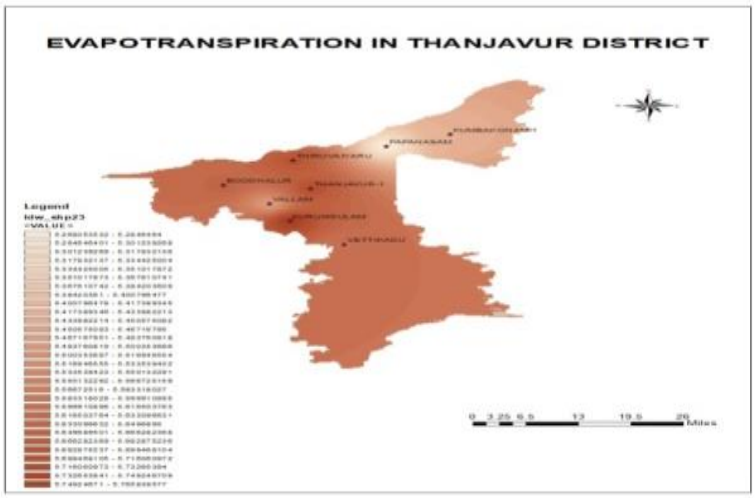

Figure 14: Evapo – Transpiration Distribution map

Comparing the G.W.L. data with change in storage

First, we find out the change in storage of the groundwater level in that site area, then these values are compared with already obtained groundwater level data from the corresponding site area in the Thanjavur district.

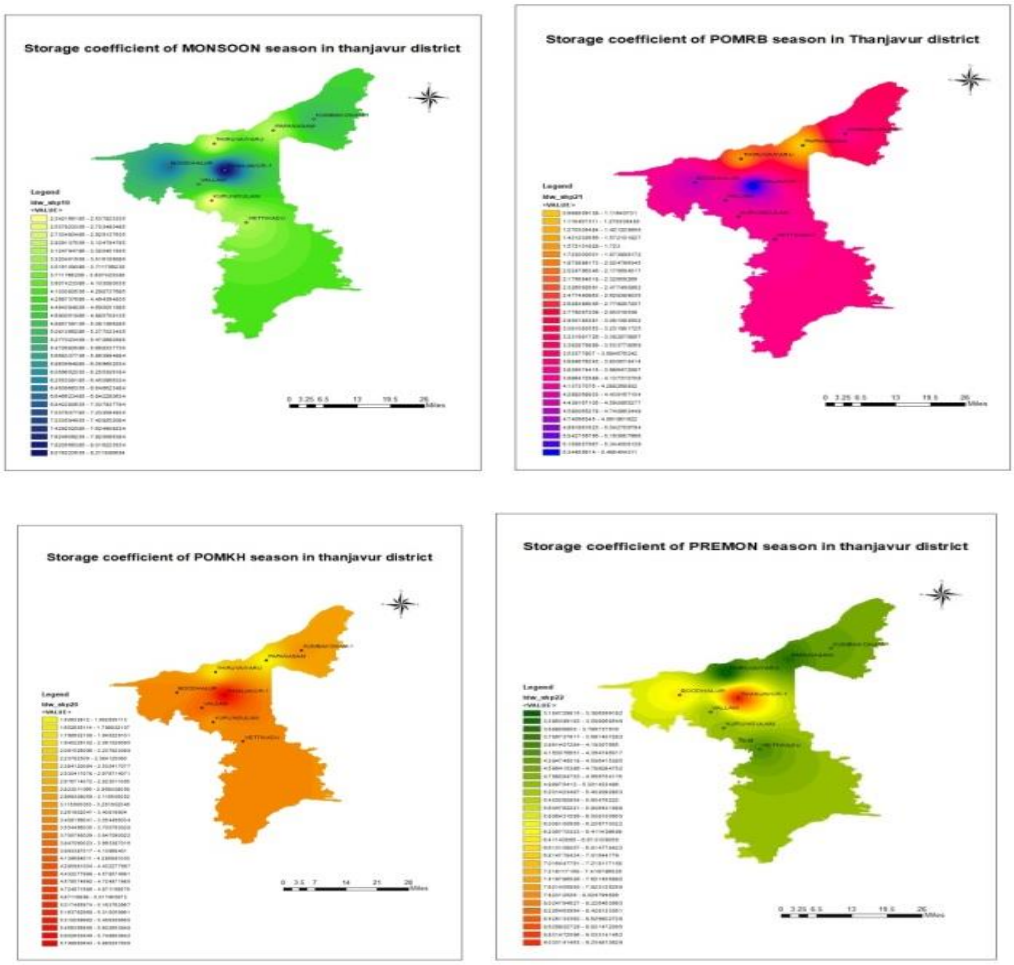

Figure 15: Storage co – Efficient map of study area

To find out the change in storage by using a given formula,

P = R+ET+ change in storage, S

Where

P is precipitation in mm, R is runoff in mm, ET is evapo -transpiration in mm/month

Table 3 shows the change in storage value of G.W.L. The above comparisons clearly show that the groundwater table level will be rise when the evapotranspiration and runoff value will be less on after that, and also it will fall its value when the higher value of those parameters.it will increase the groundwater level with the value of precipitation is more, and automatically decrease the value at temperature get increases because it influences the losses of water on it.

Table 3: Change in Storage Value of G.W.L

Si.No	Station Name	P	R	Et	S'
1.	Vettikadu	81.5	1.71	5.59	74.1
2.	Kurungulam	75.7	1.49	5.76	68.4
3.	Boodhalur	69.1	1.52	5.64	61.9
4.	Thanjavur	66.7	1.86	5.70	59.1
5.	Vallam	71.2	1.71	5.47	64.0
6.	Kumbakonam	61.3	1.70	5.41	54.1
7.	Thiruvaiyaru	69.5	1.49	5.69	62.0
8.	Papanasam	87.2	1.79	5.26	80.1

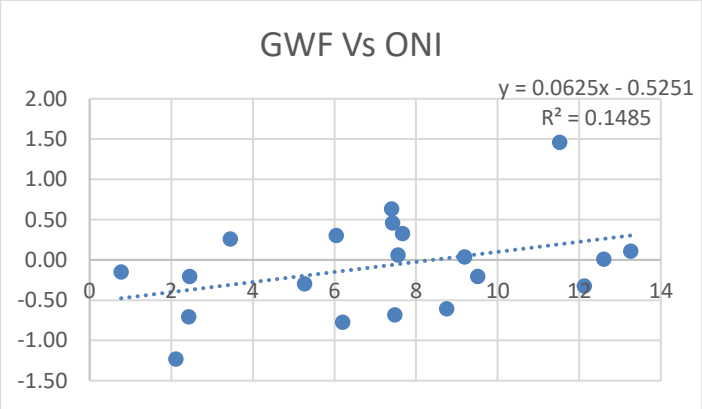

Figure 16: GWF Vs ONI

In this comparison, the groundwater level has a high value in the Thanjavur station compared to other stations' very low value in the papanasam station for change in storage level with groundwater. The storage co efficient map of the study area as shown Figure 15. (UNFCCC, 2004).

Results and Discussion:

In the above said year that El Niño occurs, that will automatically decrease the rainfall value for that area. It occurs the highest value as 12 weeks in 2006 and creates severe drought for those weeks between the years of 1999 to 2018 from the data we collected. And also that found in this study area the effect of La Niño occurs in, that causes to increases rainfall for several weeks in the year of 1999, 2000, 2007, 2010, 2011, 2012, 2015, 2018 and it will create the severe flooding on that occurs in particular weeks. Here it has a higher effect for 10 weeks in 2012 in Thanjavur district from the year 1999 to 2018.

Then, it will automatically decrease the average temperature pattern. Here this study also occurs the neutral effect in those El Niño and La Niño does not occur in those years and it will not create the severe causes. These are found that effects in this Thanjavur district.

The relationship between Ground Water Fluctuation and Oceanic Nino Index has been established to predicted future ground water Fluctuation in study area and the Equation show in fig 16.

Conclusion:

In this study, the climate change impacts on groundwater fluctuations in Thanjavur district was analyses through various analysis methods to analyze how much the impact will occur on a particular area and also it identified causes of meteorological factors like rainfall, temperature, and the effect of el Niño, la Niño , ONI and also hydrological factors like groundwater level, runoff, evapo-transpiration for this selected district from the available data collection for twenty years of 1999-2018.

From this analysis maximum rainfall occurs during 2004 to 2011 because the ONI values are moderately high in that period. The increase in ONI values the Atmospheric temperature value of study area were increased. Due to this change the runoff, ET, change in ground water storage and groundwater fluctuation is directly affected. The reaserch can therefore be concluded that groundwater levels of Thanjavur were in a state of deterioration as proved by the positive trending line Equation on fig 10. This mainly due to

change in ONI value. So, this study clearly shows that the study area is affected by means of climatic change.

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DIVERSITY OF BIVALVE MOLLUSCS FROM KARANJA ESTUARY, URAN DIST- RAIGAD (MS)

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Abstract:

The present work deals with the systematic survey of bivalve molluscs of Karanja estuary. The survey revealed a total 15 species of bivalve molluscs, these bivalves belonging to 4 families and 14 genera were recorded. The observation indicates the fragility and productivity of estuary.

Keywords: Karanja estuary, Bivalve molluscs, Systematic, Diversity.

Introduction:

Being a very specialized environment, estuaries support a wide assemblage of animal communities. It is the life habitats of many groups of animals which live entirely within. Many suspensions feeding marine bivalve molluscs live in variable environments, such as estuaries and shallow coastal waters. Many ecological and faunal survey studies have been carried out on the back waters and mangroves all over the world; some are Ganpati and Lakshmana Rao (1959) in the Godavari estuary. Berry (1964, 1972 and 1975) studied the distribution of molluscs in the Malaysian mangrove swamp, Macnae (1968) has described the general account of the fauna and flora of mangrove swamp and forests in Indo west pacific region, Subba Rao and Mookherjee (1975) in Mahanadi estuary Orissa, Hutchings and Recher (1982), Sasekumar (1981) has studied meiofauna of Malayan mangrove shore and Ashton (1999) studied biodiversity and community ecology of mangrove plants, molluscs and crustaceans in two mangrove forest in peninsular Malaysia. Subba Rao et.al. (1983) studied the malacofauna of Muriganga estuary, Sunderban. Present work has been carried out with a view to catalogue the bivalve molluscs living in intertidal sandy and muddy region of the Karanja estuary.

Material and Methods:

Samples of bivalve molluscs were collected at fortnight intervals during low tide period. The sampling procedure consist of placing series of quadrates of nylon rope of one meter square and one foot depth, by laying randomly just over the bed. The sand in the

quadrates was dug out with the help of shovel and spade and sieved through different sieves having different mesh sizes for different animals. They were thoroughly washed and passed with different grades of alcohol. Then they were preserved in 70% alcohol. Some animals were preserved in 10% formalin. Bivalve molluscs were identified according to Abbott, (1954); Macdonald, (1982), Gordon, (1990); Sowerby, (1996) and Apte, (1998).

Result and Discussion:

Table 1: Diversity of bivalves from Karanja estuary

Order	Family	Genus	Species
Arcoidea	Arcidae	*Arca*	1) *granosa* (Linnaeus, 1758)
Eulamellibranchia	Veneridae	*Meretrix*	2) *meretrix* (Linne, 1758) 3) *casta* (Chemnitz) (Preston, 1915)
		Katelysia	4) *opima* (Gmelin)
		Paphia	5) *laterisulca* (Roding)
		Gelonia	6) *proxima* (Gmelin)
		Sanguinolaria	7) *diphos* (Linnaeus, 1758,1771)
		Dosinia	8) *prostata* (Linne, 1758)
		Venerupis	9) *microphylla* (Deshayes)
		Gafrarium	10) *divaricata* (Chemnitz)
	Ostreidae	*Crassostrea*	11) *gryphoides* var *cattuckensis* (Newton & Smith)
		Saccostrea	12) *cucullata* (Born, 1778)
Mytiloidea	Mytilidae	*Perna*	13) *viridis* (Linne)
		Modiolus	14) *metcalfei* (Hanley)
		Pinna	15) *succatta*

Total 15 species of bivalves belonging to 4 families and 14 genera were recorded in survey viz. Crassostrea cuttuckensis, Saccostrea cucullata, Meretrix meretrix, Meretrix casta, Katelysia opima, Paphia laterisulca, Gelonia proxima, Sanguinolaria diphos, Dosinia prostata, Venerupis microphylla, Gafrarium divaricata, Arca granosa, Perna Viridis,

Modiolus metcalfei, Pinna sucatta (Table-1). The abundance of bivalves indicates the rich productivity of estuary. Most dominant macro faunal group recorded for Maharashtra coast are given molluscs group was represented by many important species of bivalves such as Perna viridis, Crassostrea cuculata, Pinctada sp. Meretrix casta, M. Meretrix, Gafrarium sp. etc. (Anon, 1984). The bivalve molluscs play a vital role in converting the organic matter together meiobenthos into biomass which in turn is consumed by fishes. Thus, the molluscs help in the secondary productivity and form an important component in the food web of the estuarine ecosystem (Durga Prasad et al. 2001). Due to a good food quality, they are widely exploited by local fishermen's. Many factors, both natural and manmade have been responsible for limiting the distribution of bivalve species and causing them to become rare or even extinct.

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MILLETS: THE CLIMATE-RESILIENT CROPS FOR A SUSTAINABLE FUTURE

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Abstract:

In the era of Global Climate Change and escalating environmental challenges, the exploration of sustainable agricultural practices and resilient crops has become imperative. Millets, often labeled as forgotten or minor crops, have gained attention due to their exceptional qualities for sustainable agriculture. These climate-resilient grains, including pearl millet, finger millet, foxtail millet, and sorghum, possess remarkable nutritional value and adaptability to harsh conditions. Rich in fiber, vitamins, and antioxidants, millets offer health benefits while being gluten-free and versatile for various dishes. Their cultivation presents environmental advantages, including low water requirements, natural pest resistance, and carbon sequestration, benefiting soil health. Millets' resilience to drought, heat, and water scarcity makes them ideal for water-scarce regions, and their deep roots contribute to efficient water and nutrient use. Moreover, their genetic diversity and adaptability enhance agro-biodiversity, reduce climate risks, and promote food security. Millets offer economic opportunities for small-scale farmers with shorter growth cycles and lower input needs, while their longer shelf life bolsters food security. Promoting millet-based value chains can uplift rural livelihoods. Culinary diversity and cultural heritage are also preserved through millet consumption. Embracing millets as part of diversified cropping systems strengthens resilience, addressing food security, health, and economic challenges. Therefore, prioritizing millet cultivation, consumption, and research in agricultural policies can pave the way for a climate-resilient and sustainable future.

Keywords: Millets, Climate-Resilient Crops, Sustainable agriculture, Minor crops, Carbon sequestration, Agro-biodiversity, Genetic diversity, Cultural heritage

Introduction:

In an era of Global Climate Change and increasing environmental challenges, it has become imperative to explore sustainable agricultural practices and resilient crops that can mitigate the impacts of these changes. One such group of crops that has garnered attention in recent years is millets. Millets, often considered as forgotten (Shika *et al.,* 2023) or minor

crops, possess remarkable qualities that make them a key component of sustainable agriculture. They are climate-resilient, requiring minimal water and input resources while providing multiple nutritional benefit (Sukhbir, 2017). This essay explores the significance of millets as climate-resilient crops and their potential in shaping a sustainable future.

What are millets?

Millets are a diverse group of small-seeded grasses that have been cultivated for thousands of years, primarily in Africa and Asia. These grains have gained significant attention in recent years due to their exceptional nutritional value and resilience to harsh growing conditions. Millets come in various types, including pearl millet, finger millet, foxtail millet, and sorghum, each with its unique characteristics and culinary uses. Rich in fiber, vitamins, minerals, and antioxidants, millets offer numerous health benefits, such as improving digestion, promoting heart health, and aiding in weight management. Additionally, millets are gluten-free, making them an excellent alternative for individuals with celiac disease or gluten sensitivities. Their ability to thrive in dry and arid regions makes them an ideal crop for sustainable farming and food security in areas with water scarcity and challenging agricultural conditions. Millets can be used in a wide range of dishes, including porridges, bread, pilafs, salads, and even desserts, providing a versatile and nutritious option for a balanced diet (Saxena *et al*., 2021). With their remarkable nutritional profile and adaptability, millets have emerged as a promising crop to address global food challenges while promoting healthy eating habits.

There are many types of millets but all are coming under the family Poaceae. Some of the most common millets are given below.

Sl. No	Common Name	Botanical name	Nutritive value
1	Pearl Millet or Bajra	*Pennisetum glaucum* (L.) R. Br.	• High in dietary fiber. • Good source of essential minerals like • iron, phosphorus, and magnesium. • Rich in antioxidants. • Contains complex carbohydrates. • Gluten-free.

2	Finger Millet or Ragi	*Eleusine coracana* (L.) Gaertn.	• Excellent source of calcium and iron. • Rich in dietary fiber. • Contains essential amino acids like • methionine and cysteine. • Good source of B-complex vitamins. • Gluten-free.
3	Foxtail Millet or Common Millet	*Setaria italica* (L.) P. Beauv.	• Low glycemic index, suitable for • diabetes management. • Good source of dietary fiber. • Contains minerals like iron, • magnesium, and copper. • - Rich in antioxidants.
4	Sorghum or Great millet	*Sorghum bicolor* (L.) Moench.	• High in dietary fiber. • Good source of essential minerals like • iron and phosphorus. • Rich in antioxidants. • Provides energy and stamina. • - Gluten-free.
5	Proso Millet or Common millet	*Panicum miliaceum* L.	• Good source of dietary fiber. • Provides essential minerals like iron • and phosphorus. • Rich in antioxidants. • Contains B-complex vitamins. • Gluten-free.
6	Barnyard Millet or Sanwa	*Echinochloa esculenta* Echinochloa crus-galli (L.) Beauv.	• Low glycemic index, suitable for • diabetes management. • Rich in dietary fiber. • Contains essential minerals like • calcium, phosphorus, and iron.

			• Good source of B-complex vitamins. • Gluten-free.
7	Little Millet or Kutki	*Panicum sumatrense* Roth ex Roem. &Schult.	• Rich in dietary fiber. • Good source of essential minerals like • iron, magnesium, and phosphorus. • Provides B-complex vitamins. • Gluten-free.
8	Kodo Millet or Kodon	*Paspalum scrobiculatum* L.	• High in dietary fiber. • Rich in antioxidants. • Contains essential minerals like • calcium, iron, and phosphorus.. • Good source of B-complex vitamins • Gluten-free.

The cultivation of millets offers several environmental benefits. Firstly, their low water requirement reduces pressure on water resources, allowing for sustainable water management practices. Additionally, millets are naturally pest-resistant, reducing the need for harmful chemical pesticides and promoting biodiversity in agricultural landscapes. They have a low carbon footprint due to their efficient use of resources and minimal input requirements. Millets also contribute to soil health and conservation, as their deep roots help in preventing soil erosion and improve soil fertility.

Climate-Resilience of Millets:

Millets are a diverse group of small-seeded grasses that have been cultivated for thousands of years. They have adapted to various agro-ecological regions and are known for their remarkable resilience to adverse climatic conditions. Millets exhibit exceptional tolerance to drought, heat, and water scarcity, making them well-suited for regions with erratic rainfall patterns or limited access to irrigation. Unlike water-intensive crops like rice and wheat, millets require significantly less water, making them an ideal choice for regions facing water scarcity or experiencing frequent droughts (McKena Lipham Wilson and Robert VanBuren, 2022).

Carbon Sequestration and Soil Health:

Climate-resilient agriculture aims to mitigate greenhouse gas emissions and enhance carbon sequestration to reduce the carbon footprint of farming. Millets play a crucial role in this aspect as well. These crops have extensive root systems that contribute to improved soil structure and organic matter content, enhancing soil fertility and moisture retention capacity. By sequestering carbon in the soil, millets aid in mitigating climate change while also promoting healthy and productive soils. In a study by Dongsheng *et al*. (2021), elevated CO_2 can compensate the negative effect of drought on growth of broomcorn millet, leading to a drought-mitigating effect on aboveground biomass. This was mainly attributed to elevated CO_2 induced increase in carbon uptake, which maintained a relatively high photosynthetic rate of broomcorn millet under drought. Elevated CO_2 enhanced the water use efficiency of broomcorn millet at the leaf and plant levels, especially under drought (Zehua Gong *et al.,* 2021).

Biodiversity and Adaptability:

Millets are an ancient group of crops that exhibit remarkable genetic diversity and adaptability to diverse agro-climatic conditions. They can withstand harsh environments with minimal water and nutrient requirements. Millets have the ability to grow well in both dryland and rainfed regions, making them particularly valuable in areas prone to droughts or erratic rainfall patterns. By cultivating a range of millet varieties, farmers enhance agro-biodiversity, reduce dependency on a limited number of crops, and mitigate the risks associated with climate variability.

Water Efficiency and Drought Tolerance:

Water scarcity is a critical challenge in the face of climate change. Millets possess inherent characteristics that contribute to their water efficiency and drought tolerance. These crops have deep roots that enable them to access water from lower soil layers, enhancing their resilience to water stress. Additionally, millets exhibit a C4 photosynthetic pathway, allowing them to photosynthesize efficiently even in high-temperature conditions, resulting in reduced water requirements compared to other cereal crops. By incorporating millets into cropping systems, farmers can conserve water resources and mitigate the impact of droughts on agricultural productivity. The higher water use efficiency and lesser input requirements of millets for its cultivation make them a wonderful crop for ecological balance and sustainability as compared to other cereals (Sukbir, 2017).

Nutritional Advantages:

Millets are not only resilient crops but also highly nutritious. They are rich in dietary fiber, essential minerals like iron, calcium, and magnesium, and contain a good balance of amino acids. Millets are gluten-free and have a low glycemic index, making them suitable for people with gluten intolerance or diabetes (Yewe lsew Abebe, 2007; Yadav *et al*., 2021). The consumption of millets contributes to a healthier diet and helps combat malnutrition, especially in vulnerable communities where access to nutritious food is limited (Dauakar Rao *et al*., 2017; Kumar *et al*., 2018, Ajay Kumar Chandra, 2021).

Economic Opportunities and Food Security:

The promotion of millets can provide significant economic opportunities, particularly for small-scale farmers. Millets have a shorter growth cycle compared to major cereals like rice and wheat, allowing for multiple cropping and higher yield per unit of land. They require fewer inputs and are cost-effective to cultivate, reducing production expenses for farmers. The diversification of cropping systems by including millets can also contribute to income stability and risk reduction for farmers, as they are less vulnerable to climate-induced crop failures. Furthermore, millets have a longer shelf life, enhancing food security by ensuring availability during periods of scarcity. Millets constitute one of the neglected groups of crops in India, which have tremendous potential for contributing to food and nutrition security. Millets are to be included in the Public Distribution System alongside rice and wheat so that they receive an appropriate Minimum Price Support (Shahidul Islam and Varghese Manaloor, 2021)

Livelihoods:

Promoting the cultivation and consumption of millets can create significant economic opportunities and support rural livelihoods, especially in marginalized farming communities. Millets are cost-effective to produce, require minimal inputs, and have multiple uses ranging from food to fodder, fuel, and industrial applications. By promoting millet-based value chains, governments and organizations can empower smallholder farmers, enhance income generation, and foster sustainable rural development. The importance of millets for food and nutritional security and the potential benefits of promoting their cultivation and consumption are better explained in a study by Asish Rai *et al*. (2013)

Culinary Diversity and Cultural Heritage:

Millets have deep cultural roots in many societies and play a significant role in traditional diets. They have been staple foods for centuries in various regions of the world, including Africa, Asia, and parts of Europe. Millets offer diverse culinary possibilities, ranging from porridges and flatbreads to soups and desserts. By reviving the consumption of millets, we can preserve culinary traditions, support local food systems, and foster cultural diversity.

Conclusion:

In the face of climate change, millets emerge as valuable and versatile crops that contribute to climate-resilient agriculture. Their ability to withstand adverse climatic conditions, lower resource requirements, nutritional benefits, and potential for economic empowerment make them a crucial component of sustainable agriculture. By promoting the cultivation and consumption of millets, we can enhance food security, reduce the environmental impact of agriculture, and support the well-being of farmers and communities. Embracing millets as part of diversified cropping systems not only strengthens resilience against climate variability but also addresses food security, health, and economic challenges. So promoting the cultivation, consumption, and research of millets should be a priority in agricultural policies and strategies to foster a climate-resilient and sustainable future.

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ROLE OF WOMEN IN FISHERIES

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Introduction:

Fisheries are one of the oldest food-producing sectors in the world and it continues to provide food and employment to millions globally. Fisheries activities can be looked at from two angles, the actual fishing process and the second all the activities that precede the actual fishing activity and can be grouped into ancillary and postharvest activities. Men and women can equally participate in the different activities of Fisheries. However, it is observed that the role of women is restricted to certain activities such as selling and net mending. Normally men only do the main fishing activities like going to the sea, harvesting, maintaining craft and gear. In this article, we will focus on the status of women in fisheries, along with the problems which women suffer.

Status of women in fisheries sector

Women in various cultures across various state have been an integral part of the fisheries sector. However, the role of women tends to be defined by social, political, cultural, economic framework of their functioning. The professionalization of the fisheries probably failed to include women partly because of women's lack of participation in policy planning and partly because men had envisioned the future professionalized fishery for men, without women.

- It should be considered in mind that women are an integral part of the sector, ignoring them will be like ignoring a large portion of the sector. Women make significant contributions to fishery related activities other than fishing. They play a major role in processing fish and fishery products, as well as in marketing.
- It is up most important to ask opinions from both men and women for the development and management of the fisheries sector.
- The under-representation of women in decision making, takes away a large portion of the available pool of expertise — from both the government and the community.

- Having more women in an organisation leads to better cooperation among team members and facilitates the decision-making process because mixed teams of men and women are better than single-sex groups at solving problems and spotting external threats.

Aquaculture

India, in spite of having a huge female population, still doesn‘t show much female participation in aquaculture. In India women can be seen engaged in carp breeding and nursery rearing, carp polyculture, catfish breeding, freshwater prawn breeding, ornamental fish breeding, feed preparation, culture of Spirulina and Azolla. Ornamental fish breeding has been a part of women in West Bengal. They started fish breeding in the small corners of their kitchen which later, they expanded to business of their own. Today many women are dependent on the ornamental fish breeding in many states like West Bengal and Kerala. Women in India are mainly associated with aquaculture through the prosperity of Self-HelpGroups (SHGs). Through SHGs women in small units come together and get engaged in aquaculture activities like breeding, feed preparation etc. These SHGs are also helpful in promoting savings habit and also provides small and short term loans at lower interests.

Women in harvest sector

It has widely been accepted that fishing is an activity done only by men. But women are involved in fishing activities in various parts of the world. This is usually done as a means to support the family in augmenting its income. Though the presence of women in actual sea fishing is rare, women are involved in harvesting of oysters, sea cucumbers, snails, sea urchins and other sedentary aquatic animals from near shore waters or shallow sea bottoms.

In India, the role of women in fish harvesting activity is much more visible in inland water bodies. Women use various gear like scoop nets, traps, gill nets, hook and line to harvest fish. The gear is usually primitive and the activity small scale, mainly to support household nutritional requirements.

In the North Eastern states, women fish in inland water bodies using a variety of indigenous fishing gear using locally available material like bamboo or cane along with netting material. A much more predominant activity that can be seen in states like Kerala, Tamil Nadu, Orissa, Andhra Pradesh, West Bengal, Maharashtra etc. is diving and hand picking of clam, *bechede-mer*, seaweeds etc. Women diving and collecting sedentary

animals is also seen in other countries like Japan. In Kerala, the clam pickers dive and remain under water for several minutes searching for clam, and harvest them with primitive hand held scoop nets or directly by hand. These are then placed in pots that are left floating on the surface of the water body. The activity is repeated several times till sufficient quantity is harvested. This is usually then processed at homesteads or taken to the market directly. The collection of several species mentioned earlier also follows a similar pattern. Seaweeds are harvested from the nearshore water.

Women are also engaged in harvesting shrimp seed from inter tidal regions in estuaries, that is used for culturing activity, and for crabs in marshes. However none of the harvesting activities are large scale and are comparable to the fish harvesting activities engaged in by the fishermen. Thus the contribution of women engaged in harvesting activities in India is generally small scale, subsistence and family labour oriented.

Post-harvest sector

Women have been more predominant in the post-harvest fisheries sector all over the country. The post-harvest sector includes shore based activities where the harvested fish is landed; marketing; drying; smoking; salting; fermenting; and other seafood industry oriented pre-processing and processing.

In states like Kerala, a share of the fish caught is kept apart for household purposes and either the fisherman takes it home after work or the fisherwoman collects it at the landing centres. With major fishing activities shifting to harbours as a result of changes that have taken place in the fishing crafts and gear, this role of women has diminished.

Ancillary activities

Women are also other ancillary activities like net making and mending where women are involved. Net making has always been one of the ways of raising the income of women. Most of the women were not trained in net making, but training is given regularly India, the women of Orissa form groups for mending, joining and stretching large gill-nets. In other parts, besides weaving the nets, joining and stretching them are usually done by men.

Problems

The most prominent and visible role of women in fisheries is that in marketing. Though women function as auctioneers and wholesalers in landing centres, the majority of auctioneers and wholesalers are still men. Since auctioneers play a major role in financing fishing activities, ability is a deciding factor in women in taking up this role. However

women auctioning fish is now being observed in many places. Wholesaling is again credit intensive and requires the ability to arrange for large sums of money, which again is a limiting factor in many women being in the trade. However, in Gujarat and Maharashtra, and the North Eastern states fisherwomen wholesalers are seen and they manage large quantities of fish.

The other drawbacks that fisherwomen face are difficulty in transportation, storage, handling bulk quantities, tie-up with middlemen, besides lack of access to credit from institutional agencies, and this has resulted in fewer women taking up these major marketing functionary roles and remain restricted to retailing smaller quantities of fish. Their presence in the marketing chain is indispensable in their role as retailers, in designated and undesignated markets or as head load fish marketers.

Conclusion:

In this article, we have discussed about the status of women in fisheries sector in India. Women play different role in fisheries sector even though women rarely venture into sea. The role of women is kept on increasing. However, there are lot of effort need to do. Role of women is quite impressive in maritime states, but the engagement in fisheries of women in non-maritime state are very less. To take full outcome from fisheries sector, it is very much essential to increase the involvement of women in fisheries sector.

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STUDY OF SURFACE WATER QUALITY IN THE GONDPIPRI REGION DISTRICT: CHANDRAPUR (MS)

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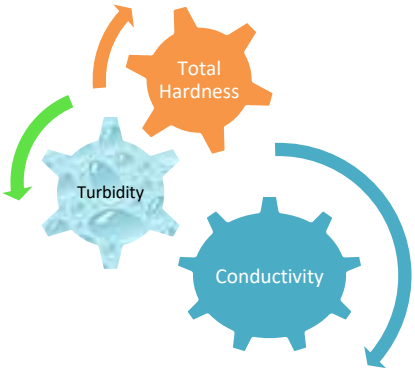
Abstract:

One of the important environmental issues in Gondpipri Tehsil is water pollution. Numerous anthropogenic activities have an impact on the quality of surface water. Numerous pollutants, including turbidity, dissolved oxygen, organic and inorganic impurities, and pesticides, chemical fertilisers are present in the surface waters. Water quality declines easily upon manmade interventions. Surface water in Gondpipri Tehsil of Maharashtra, India, has prominent physicochemical characteristics. However the locals have reported deterioration at some points. One of the sources of drinking and domestic water in this area is surface water (from lakes, rivers). These include certain inorganic and organic pollutants as well as common home and agricultural chemicals. Due to the environmental persistence of these pollutants, surface water, which is the primary source of water used to produce drinking water in Gondpipri Tehsil, may become substantially contaminated. This is because of the dumping of domestic and agricultural runoff. Currently being studied is the water quality, particularly the existence of pollutants in surface water used in Gondpipri Tehsil, and measurements of the monthly change of water quality indicators, including pH, dissolved oxygen, TDS, alkalinity, COD, and trace metal concentration. In due course the careless behaviour of Tehsil residents, such as washing and bathing in open surface water bodies and throwing rubbish into the water have deteriorated quality immensely. The analytical findings showed that there was a significant difference in the chemical composition of the examined samples. The outcome indicates that Gondpipri Tehsil water quality is poor and that water pre-treatment is required. To meet future water demand, the Tehsil must develop its water resources sustainably.

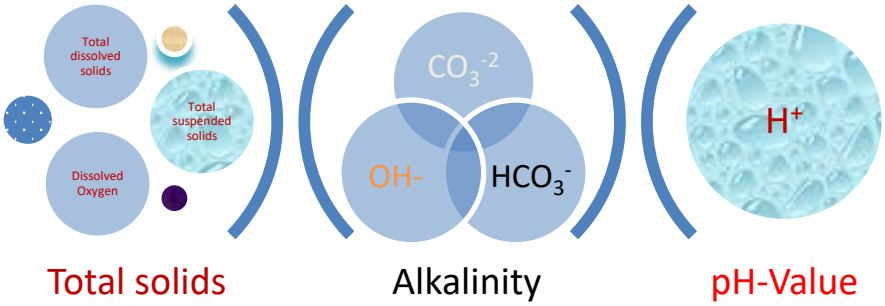
Introduction:

Surface water is typically selected as a source of drinking water due to its easy accessibility and consistent, high quality. However, the source has a number of

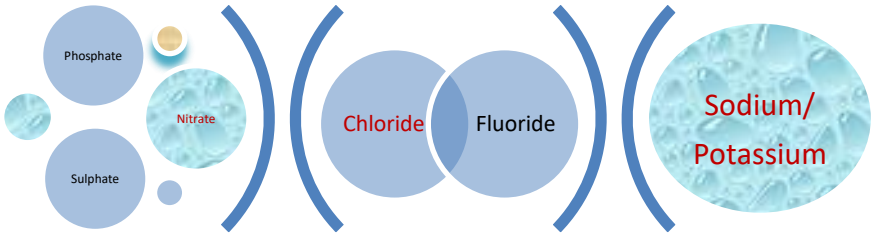
contaminants. Surface water pollution can be classified into two categories: naturally occurring pollutants and pollutants created or introduced by human activity. For instance, dust deposition, the atmospheric process of evapotranspiration, the natural leaching of organic matter and nutrients from soil, hydrological factors that cause runoff, and biological processes within the aquatic environment that can change the physical and chemical composition of water are all examples of naturally occurring substances that can pollute surface water.



Physical properties of water



Chemical Properties of water



Chemical Properties of water

Water in the natural environment therefore comprises a variety of dissolved and non-dissolved chemicals. The physical environment, the source, and the direction of the water all affect the natural quality of surface water.

Without any treatment, the residential waste produced penetrates the various locations of water bodies. Additionally, the nearby water source is contaminated by the on-going flow of agricultural waste water. The overall issue has an impact on the water supply and, eventually, human health. Since one of the three main elements of the environment is water, there is a strong correlation between the environment's quality and the health of the ecosystem. Natural bodies of water are not entirely clean because a number of organic and inorganic substances are still dissolved in them. Water quality varies physically and chemically depending on the basin's size, shape, depth, and light. The country's limited quantity of fresh water is heavily utilised in most regions. Surface water can become overloaded with nutrients and chemical waste from industrial and agricultural runoff, tainting the water supply. For sustainable development and the welfare of people, it is increasingly crucial to manage water resources effectively and control pollution, which is defined as the degradation of water's chemical, physical, and biological properties due to human and industrial activity. Water carrying dangerous chemicals is released onto the open surface as a result of industrial activities, potentially contaminating nearby surface water. A valuable natural resource and a prerequisite for life, water is. The current research was done in the Gondpipri area of Chandrapur district to examine the water quality of water body near Chintamani College. Gondpipri is in Chandrapur district, which makes up the eastern portion of the "Vidarbha" region, is situated in Nagpur Division, on the eastern border of Maharashtra. The Chandrapur district is bordered by the Wardha, Wainganga, and Penganga rivers, which are all significant. From the western border of the district, the Wardha River flows along the borders of the Warora, Chandrapur, Korapna, Rajura, Ballarpur, and Gondpipri Tehsils. The Wardha River merges with the Penganga and Irai rivers. Deccan basalts cover around 85% of the state, and Quaternary alluvium covers the remaining 15%. The entire surface water resource that can be replenished is on the order of 37.82 BCM/Yr. For the Chandrapur district, there is a provision of around 12.40 BCM/year for household, industrial, and other uses, and a provision of about 25.47 BCM/year for irrigation. Pre-monsoon (1995–2004) season saw a falling trend in surface water levels (more than 20 cm per year) near Chandrapur district.

Materials and Methods:

Method of Sampling

Water samples were gathered straight from lake near our Institution that is near by the area around Tehsil office in Gondpipri Tehsil & village crossing Wainganga River branch. The collected samples were taken month wise in April, May & June respectively, stored in a refrigerator using clean stoppered polythene bottles that had been labelled sample wise. Quarterly analysis for monthly variation was done. The water and wastewater standards [APHA-2012] approach was used for the analysis of several physicochemical parameters.

All chemicals and reagents used were of analytical grade and procured from lab, few bought from SRL chemicals Ltd. India. All Calibration Solution were made with double distilled water. The pH and electrical conductivity were measured using a digital pH metre and a conductivity metre. The alkalinity was determined using a titrimetric method with a standard sulphuric acid solution. The EDTA titrimetric method was used to determine calcium, magnesium, and chloride levels. Sodium and potassium were measured using a flame photometer. The spectrophotometer is used to measure sulphate and nitrate levels. The dichromate closed reflux method was used to conduct COD analyses. Turbidity was evaluated using a Nephelometry Turbidity metre.

Results and Discussion:

The monthly variation of physicochemical parameters of surface water in Gondpipri Tehsil, Maharashtra, is shown in Table 1. The surface water is coloured, has an odour, and is slightly salted. The pH of the research area's surface water is 7.4. Surface water has an electrical conductivity ranging from 654to799μS/cm. Higher electrical conductivity may be attributable to the sampling points' high salinity and mineral content. A high oxygen concentration usually implies good water quality. The amount of dissolved oxygen reduces as the temperature rises. Surface water has the greatest dissolved oxygen value. The dissolved oxygen in water should be between 5.5-8 ppm ideally. The term turbidity refers to the clarity of the water. Surface water has a turbidity rating ranging from 159 to 400 NTU. The bigger the number of suspended solids in the water, the higher the measured turbidity. Temperature is essential in aquatic systems because it affects the solubility of dissolved oxygen (DO) and other materials in the water column. Monthly variations in water temperature do exist and have produced fluctuating data. A pH value of 6.5 to 8.5 indicates good water quality. Natural acidity in surface water induced by carbon dioxide

dissolution in the atmosphere. Alkalinity is a related term that is usually used to describe a system's ability to buffer against acidic influences. The alkalinity ranges between 220 and 190 mg/L. Total hardness is affected by the ions Ca^{2+} and Mg2+. concentrations in the study area range from 40 to 36 mg/L. Mg2+ levels in the study area range from 16.6 to 10.2 mg/L. Mg2+ in drinking water should be at a concentration of 30 mg/L. The content of chloride in the research area ranges from 136 to 170 mg/L. Nitrate is a major source of contamination in drinking water. Water used for agricultural purposes should be suitable for both plants and animals at all times of the year but the runoffs carry immense load of impurities in due course of passage to the reservoir. Electrical conductivity (EC), salt absorption ratio, sodium percentage, and residual sodium bicarbonate are essential parameters influencing the appropriateness of surface water for irrigation applications. The samples hardness upon evaluation ranged from 124-190, while 250 is permissible.

The sodium and potassium content were 41-51 mg/l & 3-5 mg/l respectively. Whereas phosphate ranged 0.15-0.5 mg/l.

For sodium Absorption equation is,

Sodium Absorption Ratio = $Na^{+}/(Ca^{2+}+ Mg^{2+})$---------- (1)

According to Richard's Sodium Absorption Ratio value is less than 10 it is excellent, between 10-18 for an greater than 26 is poor quality. The percentage of sodium is given by the equation

% $Na=(Na^{+}+ K^{+}) \times 100/ (Ca^{2+}+ Mg^{2+}+Na^{+}+K^{+})$ ----------(2)

Most of the water samples show percentage less than 60% which indicates applicability of these water samples for irrigation purposes.

The residual sodium bicarbonate value is given by the formula

$RSC=(HCO_3^{-} + (CO_3)^{2-})-(Ca^{2+}+ Mg^{2+})$ ----------(3)

And for the water samples the values are between1.25 to 2.4 mg/l. Which indicate marginal quality of water.

Chemical oxygen demand:

Chemical oxygen demand is an important metric in the investigation of water pollution control. It is linked to organic contamination of a water or wastewater sample. Figure- D shows a monthly variation of COD concentration in surface water ranging from 8-12 mg/l and a legal limit of COD in drinking water of 10 ppm. The water level is dropping day by day though the rainfall covers it during rainy season but overall content shows net increase. As a result, the concentrations of various organic and mineral compounds in

surface water increased. As a result, the concentration of COD values rose from the first to the third month.

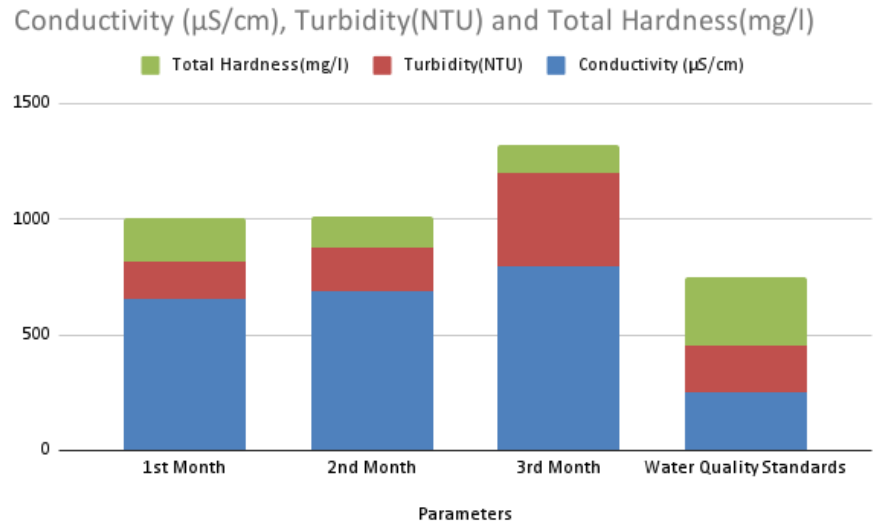
Total solids and total dissolved solids:

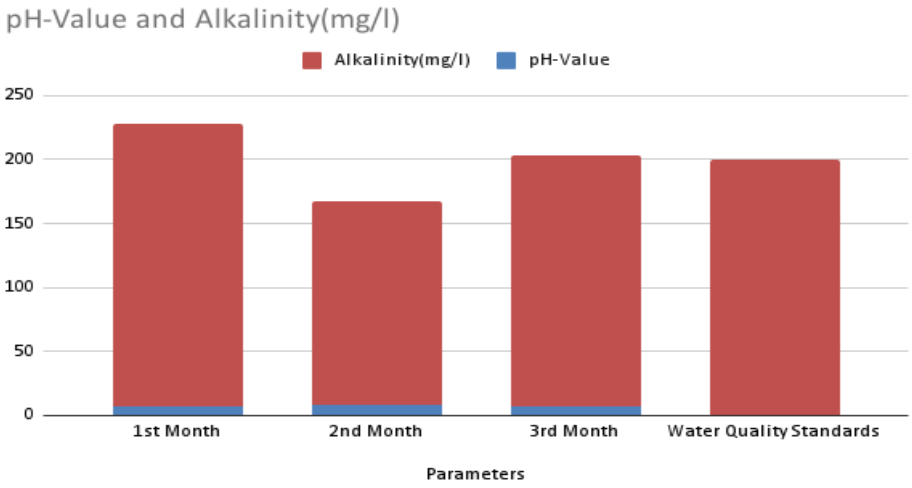
Figure C depicts a study of surface water quality comparison with Total solids and Total dissolved solids. Total solids and total dissolved solids were lowest in April and highest in June. The surface water level fell from April to June. The total concentration of dissolved solids in water determines the edaphic relationship that leads to water productivity. The total dissolved solids test determines the total quantity of minerals dissolved in water. Chloride, sulphate, calcium, and other minerals can all generate an unpleasant taste.

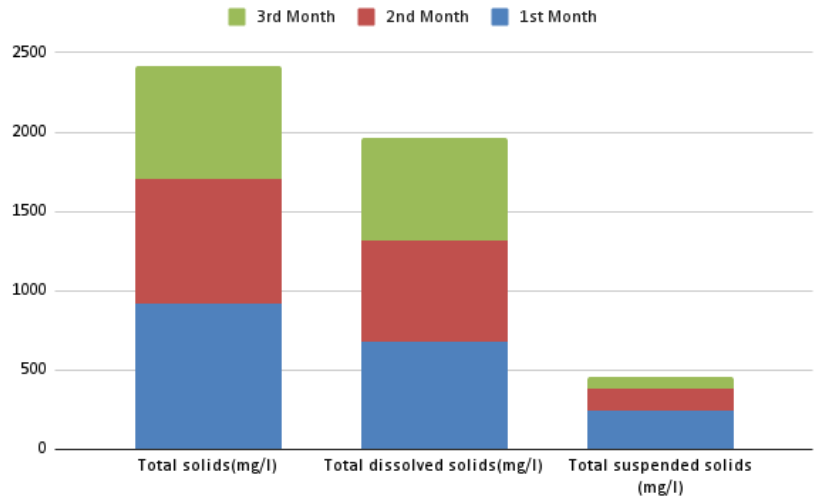
Table 1: Physicichemical analysis of water form study area

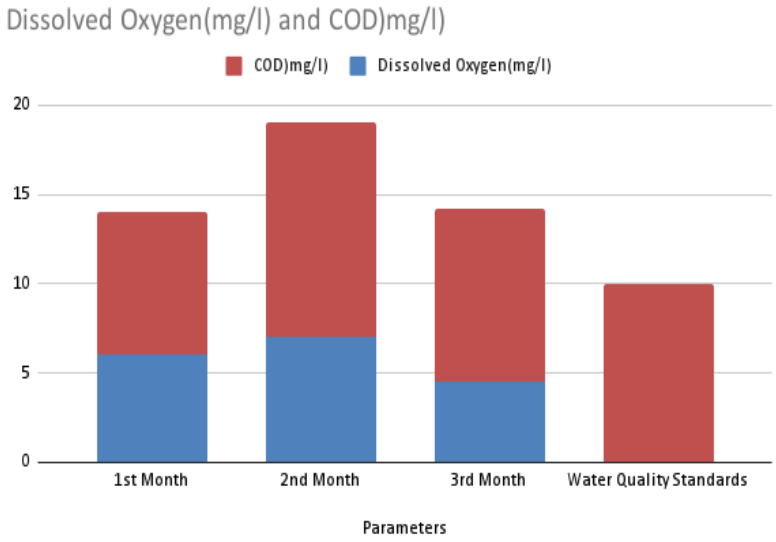
Parameters	**1st Month**	**2nd Month**	**3rd Month**	**Water Quality Standards**
Conductivity (µS/cm)	654	688	799	250
Turbidity (NTU)	160	190	400	200
Total Hardness (mg/l)	190	134	124	300
pH-Value	7.4	7.8	7.4	6.5-8.5
Total solids(mg/l)	920	780	720	-
Total dissolved solids(mg/l)	680	640	640	500
Total suspended solids(mg/l)	240	140	80	-
Dissolved Oxygen(mg/l)	6	7	4.5	5.5-8
COD)mg/l)	8	12	9.7	10
Alkalinity(mg/l)	220	160	196	200
Ca^{2+}(mg/l)	41	47	39	75
Mg2+(mg/l)	16.6	14.4	10.2	30
Chloride(mg/l)	142	136	171	250
Phosphate (mg/l)	0.5	0.4	0.15	-
Sulphate(mg/l)	30	15	5	200
Sodium(mg/l)	51	41	48	45
Potassium(mg/l)	5	0	3	-
Nitrate(mg/l)	34	49	30	45
Fluoride(mg/l)	1.8	1.5	1.9	1.4

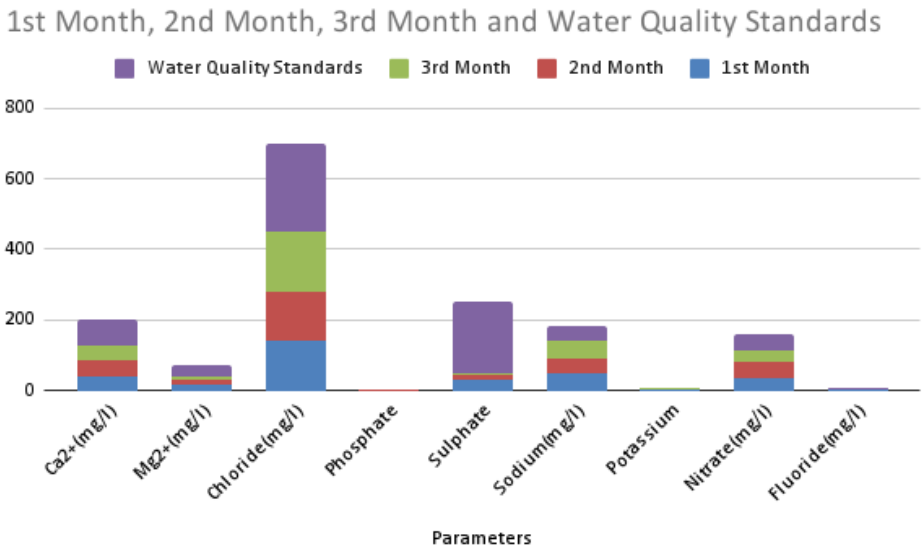
Graphical representation of physicochemical anaylis of water from study area











Electrical conductivity of the Surface water:

The concentration of dissolved salts in surface water is indicated by salination. The primary cations Calcium, Magnesium, Sodium, and Potassium, as well as the key anions Carbonates, Sulphate and Chloride, are the ions responsible for surface water salinity and conductivity. The salinity of surface water is crucial to aquatic plants and animals because many species can only thrive within specified salinity ranges. The dissolved solids in a water sample are compared to a standardised solution to determine salinity. The electrical conductivity of water is measured by how well it conducts an electric current that is proportional directly to the concentration of ions in solution. The concentration of salt in

the system is caused by the evaporation of water from the lake and ponds. A dry spell will result in an increase in salinity and conductivity value. Trends shown in figure A.

Concentration of nitrate:

The fluctuation in nitrate concentration in surface water was measured on a monthly basis. When nitrate levels are too high, it contributes to methemoglobinemia. The permissible level for drinking water set by the ISI is 45 ppm. The surface water was found to be between 30 and 49 ppm. The nitrate concentration of surface water in this location does slightly exceed the permitted levels as shown in figure E.

Fluoride:

Drinking water with a modest level of fluoride ions (F) leads to optimal oral health. A concentration of about 1.0 mg/L is useful in reducing tooth decay, especially in youngsters.

Fluoride in excess causes discoloured teeth, a disease known as dental fluorosis The maximum permitted fluoride levels in public water sources are determined by the local climate. The highest acceptable fluoride concentration for drinkable water in the country's warmer regions is 1.4 mg/L; in colder climes, up to 2.4 mg/L is permitted. The study area shows Fluoride ranging 1.5-1.9 mg/l, as shown in figure E.

Salinity:

Salinity is a significant determinant of water quality. The salinity of the water increases as electrical conductivity and total hardness value increase. Surface water from diverse agricultural lands, agricultural waste, and foliage and road run-off water raises the salinity of the water. The water is not intended for human consumption as depicted in figure B.

Dissolved Oxygen:

The level of DO in a body of surface water is a significant measure of its health. DO in water is required to sustain favourable conditions for the growth and reproduction of a normal population of fish and other aquatic organisms. The absence of a low level of DO in surface water suggests pollution caused by anaerobic bacteria decomposing organic waste, resulting in the creation of toxic end-products such as hydrogen sulphate, ammonia, and others.

Conclusions

Surface water samples can offer a more accurate picture of water quality and more flexibility in water management, according to their physicochemical properties.

Investigated was how the physicochemical properties of water samples changed on a monthly basis. Many parameters of the criteria in these reports did not meet the Indian water quality requirements (ISI). Waste water, including polluted surface water, is a major source of water-borne infections. There are communicable diseases, non-communicable diseases (such as those caused by long-term chronic exposure to hazardous substances), and water-borne diseases. Nitrate concentrations, in particular, surpass the permissible limit. A slight high COD concentration suggests that without any pre-treatment, the water is unfit for human consumption. However,Agriculture and domestic uses of surface water are both possible. Programmes should be developed to raise public awareness of the need to reduce inappropriate and wasteful use of surface water resources as well as their management and conservation. To fulfil future water demand, the area must implement sustainable surface water management. .

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STUDY OF DRINKING WATER'S PROPERTIES IN A BHANGARAM TALODHI VILLAGE IN TEHSIL GONDPIPRI, DISTRICT: CHANDRAPUR (MS)

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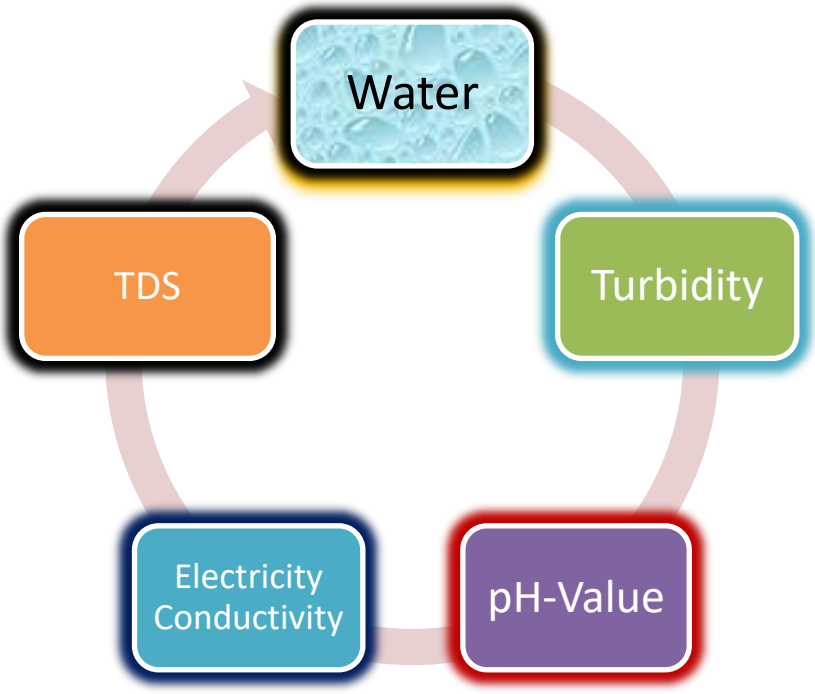
Abstract:

In this work, the quality of ground water is impacted by a variety of human activities. There are several contaminants in the groundwater and measures taken in February, including turbidity, pH value, conductivity of electricity (EC), and total dissolved solids (TDS). Ground water in the village Bhangaram Talodhi of Gondpipri Taluka of Maharashtra, India, has prominent physico-chemical characteristics. However, several instances of degradation have been documented by the people. Ground water (from hand pumps and wells) is one of the sources of drinking and domestic water in this region.

Introduction: The most ubiquitous substance on Earth and the so-called "unique solvent" is water (H_2O). Only this kind of substance can naturally exist in all three states of matter. The very polar water molecules join together to form hydrogen bonds. The high the orientation, high specific heat, high heat of vaporization, low solid density and attraction to other molecules that are polar represent the five fundamental characteristics of water.



1. Turbidity: One of the crucial aspects of water's physical makeup is its turbidity. It gauges the relative clarity of various water samples. The turbidity increases with the intensity of scattered light. Due to suspended elements like clay, silt, or other finally split biological and inorganic matter, turbidity is mostly caused by water losing its transparency. In contemporary methods, light is either measured at a 90-degree angle or as scattered light. With this, very low turbidity ranges can be measured. They are known as nephelometers and are calibrated in NTU; turbidity should be less than 1 NTU. According to the WHO (World Health Organisation), drinking water turbidity should preferably be less than 1 NTU and should not exceed 5 NTU.

2. pH Value: Water's acidity or alkalinity is determined by pH. A liquid's characteristics that include water are significantly influenced by pH. For instance, the pH of water may affect how readily available certain components, such as minerals and metals, are to the body. Because they are more readily available to the body, heavy metals in water with a lower pH tend to be more hazardous. Heavy metals would be less harmful and less accessible at a high pH. Water that is intended for use or consumption will typically remain closer to the neutral point of 7, however it may still vary significantly. The pH of drinking water should be maintained between 6.5 to 8.5, according to the Environmental Protection Agency (EPA).

3. Conductivity of electricity (EC): Deionized water is never entirely ion-free, although pure water is a good insulator. As a liquid, water passes through a process known as autoionization. Thus, one hydroxide anion (OH-) and one hydronium cation (H_3O+) can be created from two water molecules. Water's capacity to conduct electricity is gauged by its electrical conductivity (EC). The total concentration, mobility, valence, and relative concentration of ions, as well as the water temperature, are all factors that affect EC. In general, higher EC indicates that the water contains more electrolytes. Since the majority of salts can ionise, EC can also be used to indicate the entire amount of dissolved solids.

4. Total dissolved solids (TDS): All the contaminants in your drinking water are together referred to as total dissolved solids (TDS). These can include dissolved minerals, salts, metals, cations, or anions as well as organic and inorganic compounds. Parts per million (PPM) and milligrams per liter (mg/L) are the units used to measure TDS levels. More minerals are dissolved in the water as the TDS rises. Water with TDS ≤ 300 PPM is advised

to be regarded safe for drinking, according to World Health Organization (WHO) standards for the quality of drinking water. Most authorities, meanwhile, tolerate 500 PPM.

Methods:

Water samples were gathered straight from hand-pump and well of the village Bhangaram of Gondpipri Taluka in the month of February 2023. The collected samples were stored in a lab using clean plastic bottles that had been labelled sample-wise. The water and wastewater standards [APHA-2012] approach was used for the analysis of several physicochemical parameters. Turbidity was evaluated using a Nephelometry Turbidity metre. The pH-value and electrical conductivity were measured using a digital pH metre and a conductivity metre.

Analysis:

Name of Village	Sample	Temp ^{0}C.	Turbidity (<5 NTU)	pH (6.5-8.5)	EC - µS/cm	TDS (500-2000 ppm)
Bhangaram Talodhi	Source. I(i)	26	0.6	7.6	1080	702
	Source. I(ii)	26	0.4	7.3	992	645
	Source. I(iii)	26	0.4	7.7	957	622
	Source. I(iv)	26	0.8	7.3	975	634
	Source. I(v)	26	0.6	7.6	917	596
	Source. I(vi)	26	0.6	7.6	868	564
	Source. I(vii)	26	0.5	7.3	940	611
	Source. I(viii)	26	0.7	7.1	758	493
	Source. I(ix)	26	0.4	7.5	962	625
	Source. I(x)	26	0.3	7.6	1086	706
	Source. II(i)	27	0.6	7.6	1046	680
	Source. II(ii)	27	0.3	7.8	914	594
	Source. II(iii)	27	0.5	7.6	818	532
	Source. II(iv)	27	0.5	7.5	905	588
	Source. II(v)	27	0.6	7.9	1368	889
	Source. II(vi)	27	0.8	7.6	1495	972
	Source. II(vii)	27	0.6	7.4	1723	1120
	Source. II(viii)	27	0.7	7.7	1831	1190

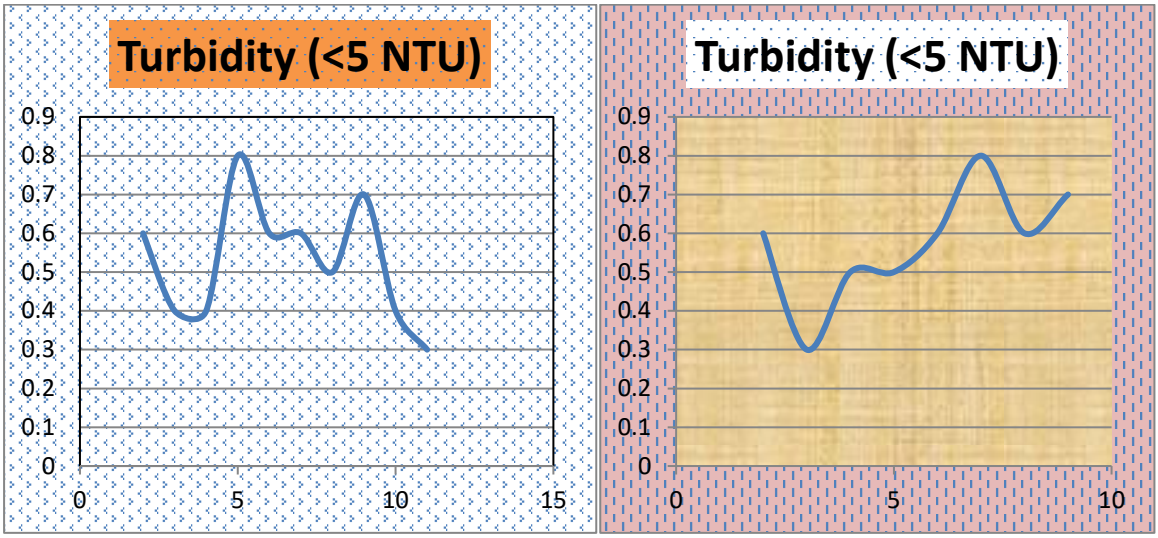


Figure 1: (i).Turbidity of Water of Source I Figure.1(ii).Turbidity of Water of Source II

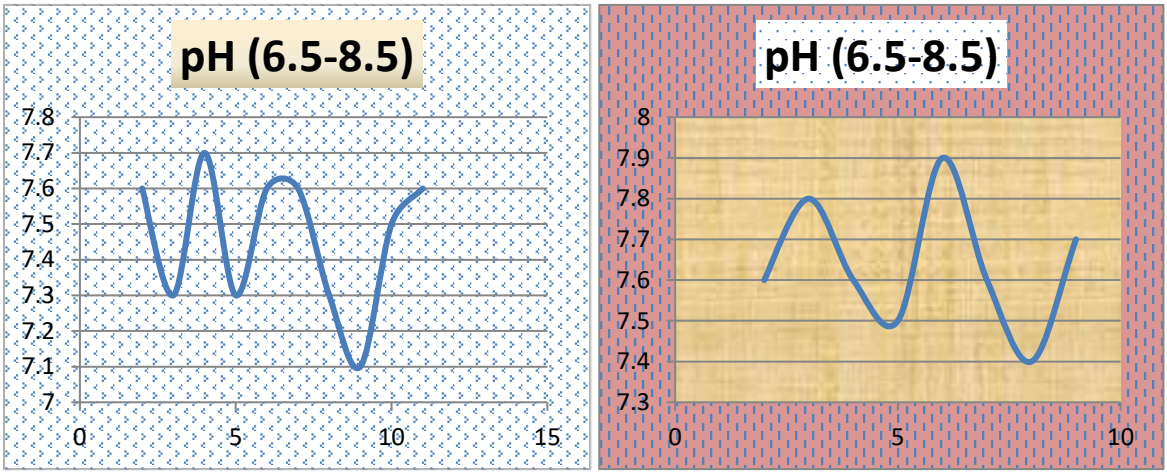


Figure 2 (i): pH-Value of Water of Source I Figure 2(ii): pH-Value of Water of Source II

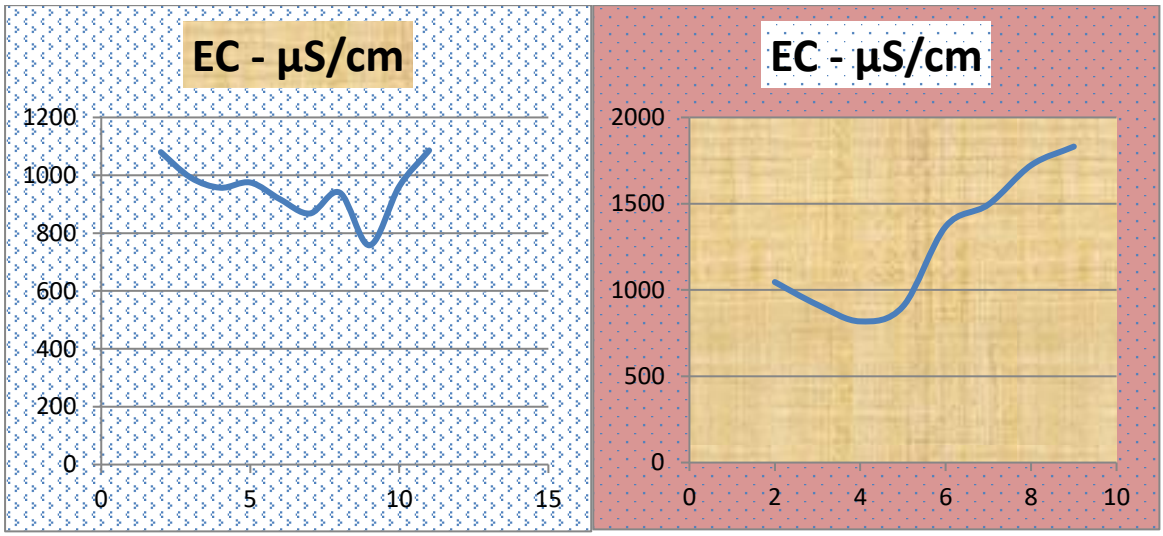


Figure 3(i): EC of Water of Source I Figure 3(ii): EC of Water of Source II

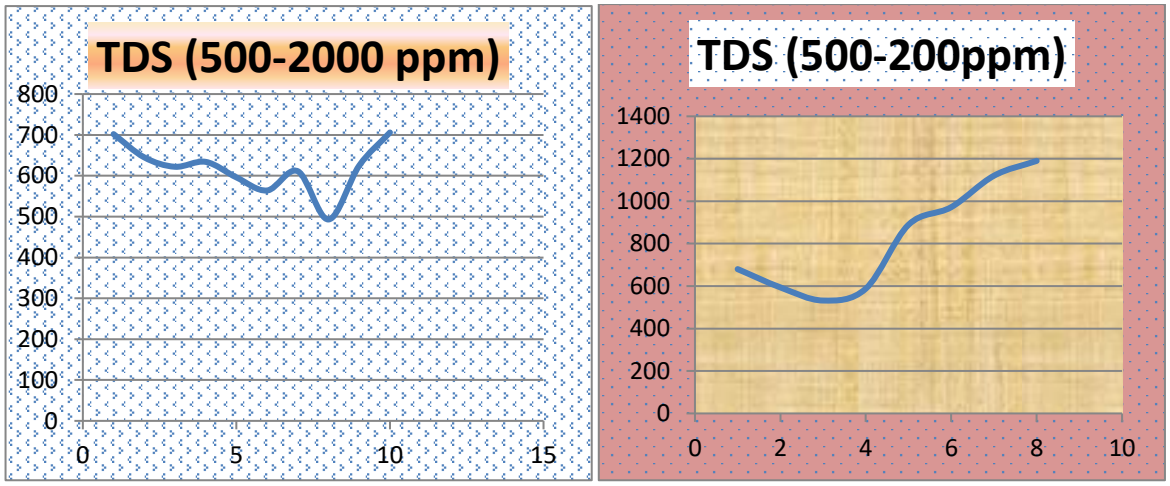


Figure 4(i): TDS of Water of Source. I Figure 4(ii): TDS of Water of Source. II

Results:

For the year 2023, the values of physico–chemical parameters of water from various sources are shown in table respectively. Throughout the study period, it was consistently discovered that the atmospheric temperature was higher than the water temperature, though the room temperature was around an average 30-35 degree Celsius during the study period the water temperature varied from 25-27 degree Celsius.

The present investigational study of samples from water sources like hand pump and well from various locations Bhangaram Talodhi of Gondpipri Tehsil have been analysed for being fit for drinking & after study of various physicochemical properties it was observed that both the waters were slightly under quality when it comes to the permissible limits of various factors. In particular out of the physical properties the turbidity of 5 out of 18 samples was less than 0.5 NTU whereas electrical conductivity of 11 source were less 1000 µS/cm,05 source was in range 1000-1500 µS/cm and 02 source were in range in 1500-2000 µS/cm and (overall was in range 750-1850 µS/cm). The PH-value of 18 samples under the standard range (6.5-8.5). The TDS of 16 samples was less than 1000 ppm, the TDS of 02 samples greater than 1000 ppm But the overall range of TDS of 18 samples under the standard range(500-2000 ppm). which indicated good properties in samples. All the above investigatory discussions have led to the conclusion that the hand pump and well water quality were of moderate nature and there is scope for improvisation to enhance the portability of water for use by the public.

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MODERN WASTEWATER TREATMENT METHODS

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Abstract:

Despite being an inorganic molecule consisting of the chemical element's of hydrogen and oxygen, water is essential to all biological life. For all socioeconomic well-beings to keep a healthy life, it is a necessary compound. Water is an odourless, tasteless liquid that may dissolve a wide range of compounds. It can absorb the entire visible, ultraviolet, and infrared spectrum and is a clear, transparent liquid. Water is abundant in the liquid state and can be found in all states of matter, including gaseous, liquid, and solid. Ice and steam are the names for the solid and gaseous phases, respectively. Water is a supercritical fluid and can occur in specific situations. World Water Day is observed annually on March 22 to raise awareness of the value of water conservation and to lessen water scarcity. Water scarcity in drought zones is a problem because as the population grows, so does the need for water. Although humans are unable to produce it, they are capable of conserving and preserving water. Several contemporary methods and tactics are currently being developed to preserve water and ensure its availability for use in the future.

Keywords: Water Sources, potable water, water pollution, water treatment methods

Introduction:

Water can be thought of as the mother and channel for all living things, as well as the matter and matrix of life. Water is necessary for life. All of the earth's life depends on water. The majority of perishable foods have high water content. It is among the essential elements required for all living things to survive. Water is a single molecule made up of two hydrogen atoms linked by covalent connections to one oxygen atom. A covalent bond is one in which the electrons are shared equally. Due of oxygen's high electronegativity, the bonds are formed. It indicated that oxygen had a built-in propensity to draw shared paired electrons to it. The water molecules' optimal shape is thought to be a linear molecule.

Water is a very small, V-shaped molecule with the chemical formula H_2O. The molecular diameter of water molecule is about 2.75Å. Water has a tetrahedral structure with oxygen atom found to be in centre and two hydrogen atoms in two corners (H-O-H). Each water molecule gets bond with the neighbouring water molecules. It is a polar molecule that can dissolve most of the substances comparing with the other natural solvents.

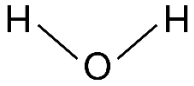

Figure 3: Shape and molecular arrangement of water

Sources of Water

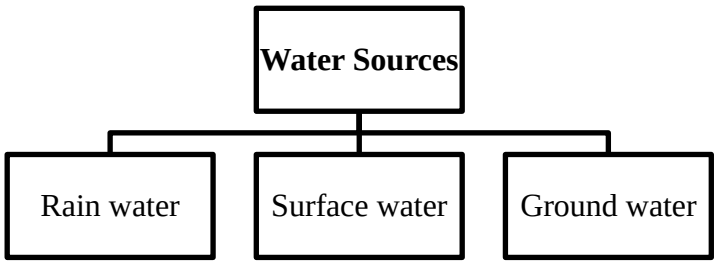

Figure 4: Sources of water

The sources of water that can be used to supply water to people are called water resources. On average, 97% of the water on earth is salt water, with the remaining 3% being fresh water. Rainwater, surface water, and ground water are the three main sources of water. In glaciers, arctic regions, fresh water is typically found in frozen states. Surface water is water that is open to the atmosphere and results overland flow. It is also considered to be surface run off water. It includes river, stream, ponds, lakes & wetland sources. The main naturally occurring channels through which extra water flows into the ocean are rivers. In general, rivers are smaller than the ocean and the sea. They emerge from the tall mountains, flow through the plains, and into the sea or the oceans. Rivers were very important in the evolution of humans. The riverbanks were close by when the first civilizations emerged. Due to heavier and longer-lasting rainfall, rivers often flow more water in the winter than they do in the summer. Groundwater is another important source of water. In general, trace amounts of calcium, sodium, magnesium, and potassium in their ionic forms can be found in ground water. The quality of ground water usually depends on the acidity of the rainwater, nature of the rock and soil in which water percolates.

Uses of Water

Water is the basis for all living beings since all plants, animals, human beings and other living organisms cannot live without water. Consumptive water and non-

consumptive water are the two basic types of fresh water. Consumptive water is used when it is instantly available. Non-consumptive water, on the other hand, needs to be treated before being used. Since sewage must undergo extensive treatment procedures before usage, it is typically regarded as non-consumptive. The main backbone of agriculture is water. According to studies, 22% of the world's water is utilised for industrial purposes, 69% for agricultural irrigation, and 8% for domestic and household purposes. Water is most used for drinking, cooking, bathing, cleaning, hygienic purposes, and gardening. Water also serves as the foundation of aquaculture. Potable water is water that is sufficiently pure to be consumed without causing any harm.

No life on earth can exist without water,
And water's ceaseless flow cannot exist without rain

Thiru Kural 20

Water Pollution and Water Scarcity

When a person lacks access to safe, inexpensive water to meet their needs for drinking, washing, or their livelihood, this is referred to as a water shortage. Studies have shown that by 2025, a third of the population in developing countries will be severely shortchanged. More than two billion people currently experience water scarcity worldwide, and India's demand for water is observed to be increasing at an alarming rate. India now has the second-largest population in the world, and it will surpass China by 2050. The biggest problem in the future will be meeting the demand for water in that situation. The main causes of water scarcity include overpopulation, agriculture, water pollution, and bad government policy. According to research by the Food and Agriculture Organization, agriculture, cattle, fisheries, and aquaculture are the root causes of water scarcity. The main cause of water scarcity is also due to climate change. Water contamination is a significant contributor to the issue of water scarcity. The largest issue that renders water unsafe for drinking is water contamination, especially in places that appear to have subpar sewage systems. Oil, animal waste, chemicals, and feces all interact with water bodies and generate pollution. Thus, it appears that water pollution renders water unsafe for use and also serves as a reservoir for diseases including dysentery, typhoid, and other water-borne illnesses. Water pollution, in addition threatens the lives of all living creatures in the water bodies and the biological diversity of ocean, sea, and aquatic environment. Water resources are chemically affected by pesticides and insecticides used for agriculture, industrialization, chemical pollutants, mining activities, radioactive wastes and so on. these chemically affected water seems to contain higher

levels of heavy metals, radioactive compounds, nitrites and nitrates, disease causing organisms, organic materials, and harmful chemicals.

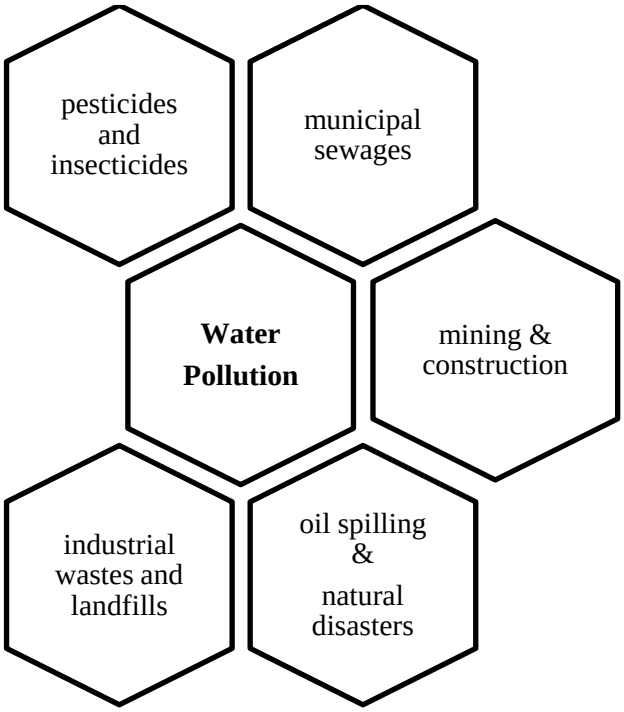

Figure 5: Factors causing water pollution

Water Conservation Methods

Human activity has contaminated water, which makes it less valuable to humans and other natural organisms. Herbicides, pesticides, fertilizers, and other pollutants may find their way into our water supply. If our water supply is contaminated, it poses a risk to the health of people, animals, and plants unless it is expensively purified. As the global population grows and the demand for water increases, there are efforts underway to learn how to conserve water through improving modern water management, water monitoring techniques.

1. Cutting down on pesticide and insecticide runoff from agriculture.
2. Limiting the discharge of untreated industrial waste into rivers.
3. promoting the use of micro irrigation methods.
4. Improving methods for recycling water.
5. Motivating individuals to actively adopt rainwater harvesting techniques.
6. Cutting back on and recycling residential water consumption.
7. Creating and putting into practice wastewater treatment plans.

Modern Practices for Wastewater Treatment Practices

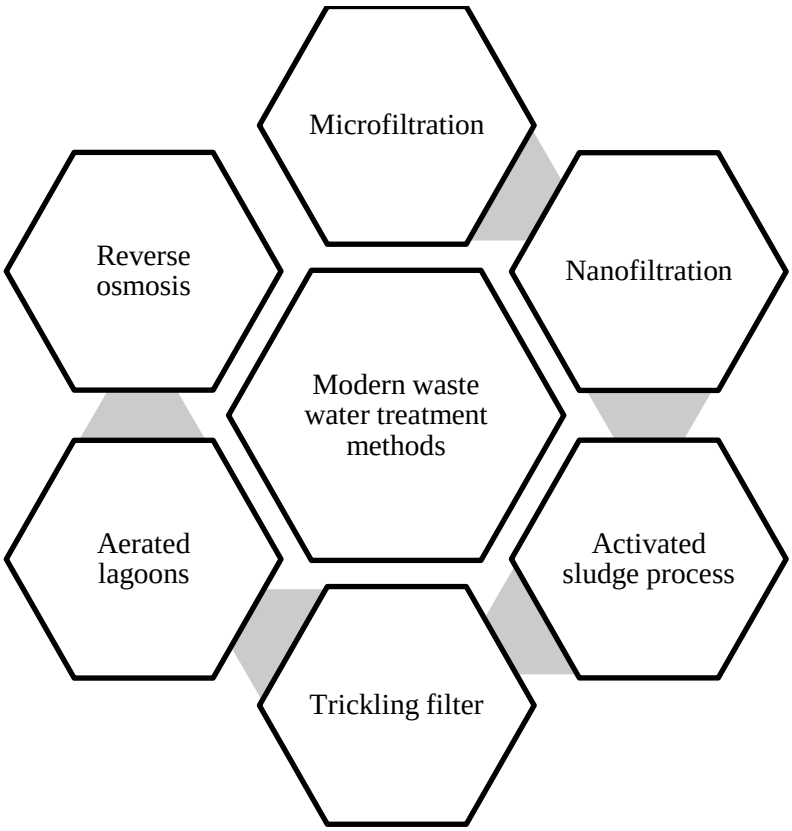

Figure 6: Modern wastewater treating methods

A) Microfiltration:

In order to remove suspended particulates from a liquid stream, a semi-permeable membrane is used in the physical separation process known as microfiltration. Various dispersed particles, disease causing pathogens, and bacteria can all be removed with its assistance. Typically, microfiltration membranes come in pore sizes ranging from 0.1 to 10 µm. Water, ions, dissolved organic matter, minute colloids, and viruses can flow through the filter membrane's porosity but bigger pollutants like algae, bacteria, pathogenic protozoa like *Giardia lamblia* and *Crypotosporidium*, sediment like sand, and clay are retained. Any solids that are too large to fit through the membrane's pores are kept while the feed stream passes through the microfilter membrane; however, any liquid or small particles are allowed to pass through. The filtrate or permeate is the portion of the feed that has passed through the filter membrane, while the retentate is the remaining portion. Cell recovery from fermentation broths, milk protein fractionation, corn syrup clarity, and CIP chemical recovery are further uses for microfiltration (MF).

B) Nanofiltration:

In waters with low total dissolved solids, filter utilising a nano porous membrane is known as nanofiltration. In addition to sanitising, it by retaining organic content, the goal is

to remove polyvalent ions. A pressure-controlled membrane is employed in the procedure, and because of its capacity to fend off ionic or molecular compounds, it serves as a filter between reverse osmosis and ultrafiltration. Organic membranes, ceramic membranes, and nanofiltration membranes can be porous or dense. The pore size of a nanofiltration filter is about 0.001 micron. Most organic molecules, almost all viruses, most naturally occurring organic debris, and a variety of salts are all removed using nanofiltration. Nanofiltration is frequently used to soften hard water.

C) Reverse Osmosis:

Reverse osmosis is a method of separation in which pressure is applied to a solution to drive the solvent through a semipermeable membrane from one area of low concentration to another area of high concentration, leaving the solutes behind. Fresh water and other small solution components can get across the barrier, while bigger molecules like salts and other contaminants cannot. The pore size of reverse osmosis filters is around 0.0001 micron. Reverse osmosis filters produce water that is almost entirely pure. Reverse osmosis eliminates all organic molecules, viruses, and the majority of the minerals that are in the water. Reverse osmosis desalinates water by removing monovalent ions from the water. Osmosis happens when two salt solutions with various salt concentrations are separated by a semi-permeable membrane. Since the semi-permeable membrane enables water to pass through but not salt, water will move from the weaker solution to the stronger solution until the two solutions are of the same concentration. In reverse osmosis, pressure is used to counteract the water's natural flow while the two solutions are still separated by a semi-permeable membrane. This forces the water to go from the stronger solution to the one that is more concentrated. As a result, the pure water is on the other side of the semi-permeable membrane and the contaminants are on one side. Reverse osmosis eliminates all organic molecules, viruses, and the majority of the minerals that are in the water.

D) Activated Sludge Process:

The activated sludge technique is the biological method that is most frequently employed for the treatment of industrial and municipal waste fluids. This particular biological wastewater treatment is one of many. The organisms in this combined liquor work swiftly to break down the wastes in the wastewater being treated when activated sludge is added. The mixed liquor typically travels to a separate tank called a clarifier where the activated sludge is allowed to settle out and the residual liquid is discharged as effluent after the necessary period of aeration and agitation in the aeration tank. The

settled sludge is either discarded as waste activated sludge or recycled as return activated sludge in the aeration tank. To keep the population of organisms in the aeration tanks at an adequate level, some sludge must always be added back. • Microorganisms feed and multiply on waste particles in the wastewater when wastewater is fed to activated sludge.

- Waste is eliminated, and wastewater is partially cleaned as organisms multiply and thrive.
- Organisms require a balance of food (BOD) and oxygen. Equipment used for aeration adds oxygen.
- The food to microorganism ratio, or F/M ratio, refers to the proportion of food to organism mass. For the activated sludge process to function properly, a suitable F/M ratio is required.
- The activated sludge technique for waste treatment removes soluble or suspended materials.
- Carbon dioxide, water, sulphate, and nitrate chemicals are produced by organism activity.
- During sedimentation, remaining solids are transformed into a form that allows them to settle and be removed as sludge.

E) Trickling Filter:

One of the techniques for aerobic wastewater treatment is the trickling filter procedure. This fixed-bed bioreactor removes large particles, suspended organic and inorganic waste, tiny colloids, and other contaminants from primary effluent as part of secondary wastewater treatment. Since a trickling filter uses active microbial mass as a bioweapon to break down waste from primary sewage, it is also known as a biological filter. In a trickling filter, pretreated wastewater is sprayed over a bed of gravel or plastic particles. Microorganisms cling to the media in the bed of trickling filter systems and cover it with a biological coating. The microorganisms devour and eliminate impurities from the water as the wastewater trickles through the media. Municipal wastewater treatment often used trickling filters. A septic tank, clarifier, trickling filter are the components of each trickling filter system. Septic tank separates the settleable and floatable materials from the wastewater, a clarifier enables biological waste to remove itself from the water by settling. A tank containing media, such as gravel or plastic, trickles through the filter. A thin film of wastewater runs downward across the media's surface after being distributed over the top of the medium. After that, it leaves the tank's bottom and enters the clarifier.

F) Aerated Lagoons:

One of the aerobic suspended growth techniques is aerated lagoons. Aerated lagoons are basins where wastewater is either flowed through or treated with solids recycling. Instead of using photosynthetic oxygen yield as is the case with oxidation ponds, diffused air aeration units, surface aerators on floats, fixed platforms, or other air-aeration systems are typically employed to supply oxygen. The contents of the basin are kept suspended by the aerators' activity as well as the rising air bubbles from the diffuser. They are built with varied depths between 2 and 5 metres. Aerated lagoons have the advantages such as ease of operation and maintenance, equalization of wastewater, and a high capacity of heat dissipation when required. The disadvantages of aerated lagoons large area requirement, difficulty in process modification, high effluent suspended solids concentration, sensitivity of process efficiency to variation in ambient air temperature.

Conclusion:

One of the largest crimes that goes unpunished is wasting water. Each and every person has a responsibility to look for solutions to reduce water waste. In and around our homes, schools, and places of employment, there are numerous ways to conserve water. Be the first to save water rather than waiting for someone else to do it. Water is the source of all life on earth. Even though there is a lot of water on the planet, just 3% of it is acceptable for human consumption. The only way to safeguard us from impending water scarcity and water-threatening issues is through water conservation. There are just a few techniques for reducing water contamination. However, there are many highly accessible and economical technologies and methods for water recycling and conservation.

Save water now or pay for it later.

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