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Analysis of Seawater Intrusion of Groundwater Samples at Krishna District

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Abstract- **Many areas of the world use groundwater as their main source of fresh water supply. With the world's population increasing at alarming rates, the fresh water supply is being continually depleted, increasing the importance of groundwater monitoring. One of the major concerns most commonly found in coastal aquifers, is the induced flow of salt water into fresh water aquifers caused by groundwater development, known as salt-water intrusion. In places where groundwater is being pumped from aquifers that are in hydraulic connection with the sea, the induced gradients may cause the migration of salt-water from the sea toward the well.**

Key words: Seawaterintrusion, Groundwater, aquifer, freshwater, percolation, salt water

I INTRODUCTION

Seawater intrusion is the movement of seawater into fresh water aquifers due to natural processes or human activities. Seawater intrusion is caused by decreases in groundwater levels or by rises in seawater levels.

When fresh water is withdrawn at a faster rate than it can be replenished, the water table is drawn down as a result. This draw-down also reduces the hydrostatic pressure. When this happens near an ocean coastal area, salt water from the ocean is pulled into the fresh water aquifer. Because of seawater intrusion most of the fertile lands has become wastelands and cultivation has decrease. Inhabitants of this region are facing water Problem. The main sources of saline intrusion are

1. Change of land use from agriculture to residential
2. Increase in the number of bore wells or dug wells and hand pumps

Thus pumping of excessive ground water may be a cause for the possible intrusion of seawater in the delta region. High concentrations of chloride can make water unfit for human consumption and for many industrial uses, but the human health-related problems have not been carefully observed yet. High concentrations of sodium ion can contribute to certain heart disease or high blood pressure, particularly in susceptible individuals.

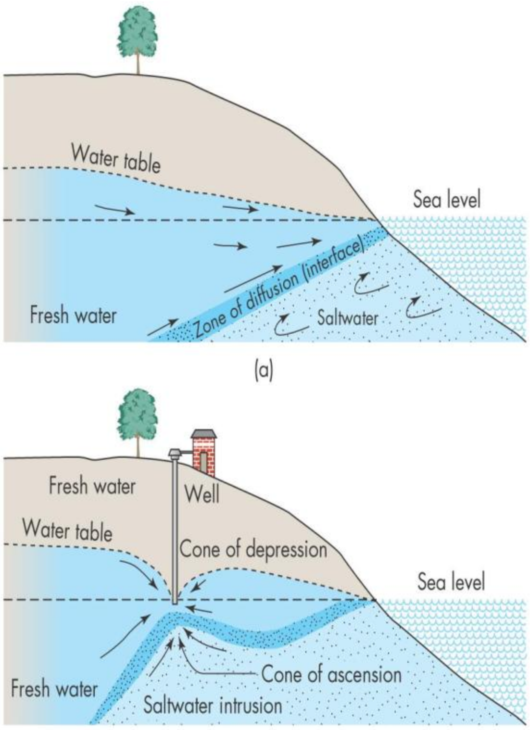
High concentration of chloride has bad effects on the environment as well: it can produce leaf burn and even defoliation in sensitive crops; in lakes can increase the presence of metals in waters and prevent the distribution of oxygen and nutrients and thus harm aquatic life. The key to controlling this problem is to maintain the proper balance between water being pumped from the aquifer and the amount of water recharging it. Constant monitoring of the salt-water interface is necessary. In the present study, 32 ground water samples were collected from the Krishna delta region.

Water becomes salty to taste for most people at 250mg/It. Sustained usage of seawater tainted drinking water at 250mg/It or over could potentially cause health problems, however the issue is largely portability chloride-rich water will corrode metal pipes, cause leeching and can reduce the life span of your plumbing and will kill some varieties of plant life such as lawn grasses. Those who live in seawater intrusion areas needs to be aware that they are activities can render their well or neighbor's wells-useless as a source of drinking water or for watering their yard or garden. Infringing upon someone else's ability to utilize their well, particularly if their well predates yours, could resist in costly fines or litigation.

Where seawater intrusion is occurring can be determined rather simply. Predicting where seawater intrusion will occur can be technically very difficult and expensive. Several generalizations can be made about prediction: 1) any over draught aquifer that outcrops with the coastline at or below sea level will experience seawater intrusion. 2) Defining where precisely seawater will occur requires detailed analysis of well logs, long term monitoring of water levels and water quality, sub meter accurate surveying of wells and often numerical or computer modeling.

Seawater intrusion is a problem that often times is recognized too late and long after the damage to the aquifer has been done. The most obvious remedy is to step down or reduce your rate of pumping. Employ common sense water conservation measures in your own home (stop watering lawn, install low flow fixtures, use dishwasher and clothes washer only for full loads etc.

Conservation measures can be performed before a problem arises. If no improvement is noticed, stop pumping altogether for several weeks. If problems persist, you will likely need to stop use the well until the aquifer is recharged and invest in a low flow or alternative water system.



Use of salt for highways deicing is another source of contamination: when this salt washes off roads, it may easily move with percolating water into underground aquifers. An additional problem is created by the fact that piles of salt to be used for deicing have frequently been stored uncovered along roadsrain or snowmelt can dissolve this salt and, though percolation, introduce it into aquifers. More than 70% of the population depends on ground water for which hand pumps, dug wells and dug cum bore wells are used. During the past few decades, the rapid increase in seawater intrusion has caused the transformation of fresh ground water to brackish or saline water.

II SAMPLING PROCEDURES

Ground water samples were collected in polythene bottles for the analysis of major cat ions & anions. Ground water from each dug well was sampled at 0.5m below the water table. Hand pumps were run for 5 min before the collection for the samples. The water sample was also collected for trace elements, for this, a 100 ml polythene bottle was used. Soon after collection of sample .1 ml, HNO_3 was added and the sample bottle was kept airtight.

Collection of samples was of two types:

A Hand Pump:

The simplest type of reciprocating pump, which is still widely used in Indian villages & towns and sometimes in cities too, is a hand operated well pump.

B.Dug Well:

These are constructed by open exaction with hand tools like pick axes and Shaw ells or sometimes by blasting in rocky formations. After excavation is completed, well staining with masonry or concrete cavity blocks is constructed. The weep holes are provided in staining to permit water in to the well. The wells in rocky formations may be left unlined. A parapet is constructed above ground level and a circular platform is provided around the well. Provision for drawing water is made by either rope or bucket or pumping. These wells are suitable for sufficiently hard.

III - SOURCES AND MECHANISMS OF SALT WATER INTRUSION

The possible sources of saline water in a coastal aquifer may be either one or a combination of following:

1. Intrusion of salt water from the sea.
2. Presence of salt domes in geologic formations.
3. Seawater present in aquifers from past geologic times.
4. Salts in water concentrated by evaporation in tidal lagoons. Playas or other enclosures.
5. Return flow from irrigation.
6. Leakage from sewer systems and industrial effluents etc.

The mechanisms of salt-water intrusion may be broadly classified in to the following categories:

a. Reduction or reversal of water table gradients due to heavy pumping, which permits the heavier saline water to displays the lighter fresh water.
b. Destruction of natural barriers that separate fresh and saline water e.g., construction of a coastal drainage canal, which enables tidal water to advance inland and infiltrate in to the adjacent fresh water aquifer, and
c. Improper sub surface disposal of waste saline water into disposal wells or landfills.

IV- COASTAL HYDROGEOLOGY

In some areas, coastal hydro geologic conditions may simply be represented by a confined, unconfined or island aquifer. In other cases, the hydro geologic setting may be that of a multi-layer aquifer system. In either situation, the aquifer system has a sea front so that there is a direct contact in some areas, coastal hydro geologic conditions may simply be represented by a confined, unconfined or island aquifer. In other cases, the hydro geologic setting may be that of a multi-layer aquifer system. In either situation, the aquifer system has a sea front so that there is a direct contact between continental fresh water and marine salt water. Besides a slight difference in viscosity between the two fluids, there exists a density change that depends mainly on salinity differences.

Under natural, undisturbed conditions, a seaward hydraulic gradient exists in the aquifer with fresh water discharging in to the sea. The heavier salt water flows in from the sea and a wedge shaped body of salt water develops beneath the lighter fresh water, with the fresh water thickness decreasing from the wedge toe towards the sea.

The fresh water/salt water interface is stationary under steady conditions with its shape and position determined by the fresh water head and gradient. Inland changes in recharge or discharge modify the flow with in the fresh water region, including a corresponding movement of the interface. A reduction in fresh water flow due to over-draft, causes the interface to move inland and results in the intrusion of salt water in to the aquifer. Conversely, the interface retreats following an increase in fresh water flow. The rate of interface movement is governed by the boundary con Salt-water encroachment, resulting from human action, can be either active or passive.

Passive salt-water intrusion occurs when some fresh water has been diverted from the aquifer, but the hydraulic gradient in the aquifer is still towards salt-water freshwater interface. In this case, the interface slowly shifts landwards until it reaches an equilibrium position based on the reduced fresh water discharge from the coastal aquifer. Passive salt-water intrusion is taking place in many coastal aquifers where ground water resources are being developed. It occurs slowly and in some areas may take hundreds of years for the boundary to move a significant distance.

The consequences of active salt-water intrusion are considerably more severe. It takes place when the natural hydraulic gradient has been reversed and fresh water actually moves away from the salt-water freshwater interface. The interface moves much more rapidly than it does during passive salt-water intrusion.

V- RESULTS AND DISCUSSION

23 samples were collected from various villages at various distances in and around Krishna district during the years January – 2010 and January - 2011 and chemical analysis for various parameters has been done. Results have been presented below in the name of January – 2010 and January – 2011 tables.

The report may be useful to understand spatial distribution of water quality parameters and ground water levels in the study area and also for further studies.

Table 1 Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2011

Sl. No	Name of The Village	Type of well	Depth (m)	Location
1	MACHILIPATNAM	D.W	4.57	Zphvigneswara temple
2	KODURU	D.W	4.28	Ptchamma temple
3	AVANIGADDA	H.P	6.10	Shiva temple
4	NGAYALANKA	H.P	6.10	Venkateswara temple
5	GUDLAVALLERU	D.W	6.10	Near iron bridge
6	GUDIVADA	D.W	6.71	Near model public school
7	PEDAPARUPUDI	D.W	7.62	Near ayyappa temple
8	PEDANA	D.W	4.88	Royal wines near
9	PAMARRU	H.P	4.57	Near highway
10	PEDAMADDALI	H.P	5.48	Near rama temple
11	GUDURU	D.W	4.27	Near Ramakrishna theater
12	MOPIDEVI	H.P	3.66	In venkateswara temple
13	CHALLAPALLI	D.W	4.57	In ayyappa temple
14	GHANTASALA	D.W	7.62	Near welding market
15	ENDAKUDURU	D.W	6.10	Only one well
16	MOVVA	H.P	24.38	Near peddacheruvu
17	PALANKIPADU	D.W	5.49	Near milk booth
18	KAZA	D.W	4.27	Near periphery of kaza
19	NIDUMOLU	D.W	6.10	Near masjid
20	PAMIDIMUKKALA	D.W	6.50	Veterinary hospital
21	THADANKI	D.W	6.10	Near cheruvu
22	MEDURU	D.W	5.25	Near meduru center
23	MARRIVADA	D.W	6.10	Entrance

Table 2 Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2011

Sl.No	Name of The Village	Total hardness (ppm)	Ca (ppm)	Mg (ppm)	pH	Alkalinity
1	MACHILIPATNAM	385.61	9.8	348.23	7.82	308.21
2	KODURU	735.49	11.54	739.05	7.80	919.07
3	AVANIGADDA	427.31	5.52	441.79	7.62	736.33
4	NGAYALANKA	416.96	4.16	413.02	7.38	716.55
5	GUDLAVALLERU	309.45	5.43	214.2	7.52	380.30
6	GUDIVADA	992.4	25.01	967.39	7.41	1108.54
7	PEDAPARUPUDI	327.34	6.354	360.8	7.65	901.20
8	PEDANA	817.00	22.18	814.82	8.01	954.79
9	PAMARRU	613.8	11.88	612.1	6.98	792.15
10	PEDAMADDALI	695.44	4.98	690.36	7.42	622.59
11	GUDURU	305.99	6.54	318.45	7.29	3415.75
12	MOPIDEVI	744.3	21.63	745.67	6.87	965.06
13	CHALLAPALLI	463.12	5.13	459.99	8.01	844.42
14	GHANT	1050.8	21.4	1203.	7.87	716.1

	ASALA	8		49		0
15	ENDAKUDURU	998.31	13.45	1112.09	7.54	799.21
16	MOVVA	101.21	19.45	81.21	8.09	412.66
17	PALANKIPADU	2841.01	33.06	1999.2	7.12	652.21
18	KAZA	999.21	9.34	1381.22	7.26	989.24
19	NIDUMOLU	537.5	7.21	532.26	7.52	621.14
20	PAMIDIMUKKALA	201.54	4.26	203.29	7.53	599.47
21	THADANKI	480.42	10.24	372.41	7.85	457.17
22	MEDURU	297.72	2.92	294.80	7.87	570.45
23	MARRIVADA	430.04	4.31	425.73	8.01	906.27

Table 3 Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2011

Sl. No	Name of The Village	Na (ppm)	K (ppm)	Chlorides (ppm)	TDS (ppm)
1	MACHILIPATNAM	30	12	1184.38	780
2	KODURU	103	26	2620.47	1802
3	AVANIGADDA	70	2	1590.35	1432
4	NGAYALANKA	64	1	1463.85	1125
5	GUDLAVALLERU	21	0	560.24	598
6	GUDIVADA	135	5	4156.6	2986
7	PEDAPARUPUDI	64	2	1445.78	1958
8	PEDANA	100	36	3614.44	2458
9	PAMARRU	122	5	2704.79	1989
10	PEDAMADDALI	63	3	1789.15	2002
11	GUDURU	22	5	668.67	650
12	MOPIDEVI	65	30	2077.09	2030
13	CHALLAPALLI	66	2	1554.21	1420
14	GHANTASALA	128	121	6144.54	3362
15	ENDAKUDURU	260	16	1020.78	4892
16	MOVVA	64	1	1066.26	1054
17	PALANKIPADU	324	4	1872.81	6541
18	KAZA	126	98	5650.56	3960
19	NIDUMOLU	66	4.32	1807.22	1548
20	PAMIDIMUKKALA	42	7.02	867.47	889
21	THADANKI	11	7	813.52	895
22	MEDURU	29	24	885.54	1124
23	MARRIVADA	68	0.04	4518.06	1890

Table 4 Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2010

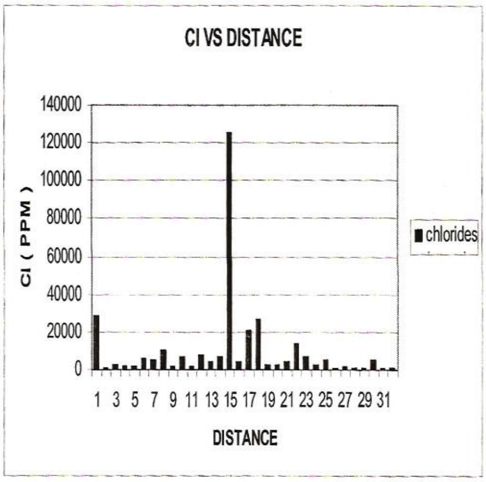
Sl.No	Name of The Village	Type of well	Depth (m)	Location
1	MACHILIPATNAM	D.W	1.21	Zphvigneswara temple
2	KODURU	D.W	4.28	Ptchamma temple
3	AVANIGADDA	H.P	6.13	Shiva temple
4	NGAYALANKA	H.P	6.15	Venkateswara temple
5	GUDLAVALLERU	D.W	6.10	Near iron bridge
6	GUDIVADA	D.W	36.36	Near model public school
7	PEDAPARUPUDI	D.W	12.12	Near ayyappa temple
8	PEDANA	D.W	10.6	Royal wines near
9	PAMARRU	H.P	4.54	Near highway
10	PEDAMADDALI	H.P	5.48	Near rama temple
11	GUDURU	D.W	4.27	Near Ramakrishna theater
12	MOPIDEVI	H.P	6.06	In venkateswara temple
13	CHALLAPALLI	D.W	5.15	In ayyappa temple
14	GHANTASALA	D.W	6.06	Near welding market
15	ENDAKUDURU	D.W	6.10	Only one well
16	MOVVA	H.P	13.63	Near peddacheruvu
17	PALANKIPADU	D.W	9.09	Near milk booth
18	KAZA	D.W	14.24	Near periphery of kaza
19	NIDUMOLU	D.W	6.06	Near masjid
20	PAMIDIMUKKALA	D.W	12.12	Veterinary hospital
21	THADANKI	D.W	78.78	Near cheruvu
22	MEDURU	D.W	30.3	Near meduru center
23	MARRIVADA	D.W	12.12	Entrance

Table 5: Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2010

Sl. No	Name of The Village	Total hardness of $CaCo_3$ (ppm)	Ca (ppm)	Mg (ppm)	Chlorides (ppm)	pH
1	MACHILI PATNAM	52.0	8.8	43.2	2489.9	6.9
2	KODURU	425.0	6.35	418.65	667.81	7.05
3	AVANIG ADDA	937.4	11.53	925.87	1575.08	7.63
4	NGAYAL ANKA	940.0	2.16	937.84	1441.89	6.42
5	GUDLAV ALLERU	830.0	5.26	824.74	2136.71	6.25
6	GUDIVA DA	224.0	1.28	22.72	7130.89	6.96
7	PEDAPA RUPUDI	730.45	11.42	718.58	6213.36	6.90
8	PEDANA	590.80	16.32	573.68	7876.91	6.71
9	PAMARR U	2360	22.53	2337.47	1221.23	6.31
10	PEDAMA DDALI	234.57	3.84	230.73	5323	7.53
11	GUDURU	247	7.8	239.20	2100	7.39
12	MOPIDE VI	375.40	12.94	362.46	6878.25	7.43
13	CHALLA PALLI	722.13	4.6	717.40	5893.65	7.66
14	GHANTA SALA	282.75	6.73	275.27	8454.07	7.53
15	ENDAKU DURU	743.09	7.659	735.34	56254.6	7.47
16	MOVVA	220.23	1.88	218.12	2931.2	7.09
17	PALANK IPADU	240.17	10.39	229.61	22326.45	7.42
18	KAZA	550.01	8.11	541.89	25029	7.12
19	NIDUMO LU	660.44	10.39	649.61	3586.25	6.52
20	PAMIDI MUKKA LA	74.23	1.68	72.32	3212.46	8.46
21	THADAN KI	160.42	9.85	150.15	11454.5	8.18
22	MEDUR U	570.13	7.862	802.14	5638.56	8.15
23	MARRIV ADA	72.2	2.12	69.88	3266	6.84

Table 6: Chemical Composition Of Ground Water In Krishna Delta Confined To Krishna District During January – 2010

Sl.No	Name of The Village	TDS (ppm)	Na	K	Alkalinity (ppm)
1	MACHILIPATNAM	26029.4	139.3	21.2	475
2	KODURU	529.80	124.9	10.1	725.56
3	AVANIGADDA	2118.80	140.8	4.4	188
4	NGAYALANKA	1283.82	596.6	20.6	372.57
5	GUDLAVALLERU	1925.57	118.9	11.7	555.79
6	GUDIVADA	5052.1	550.6	9.8	979.07
7	PEDAPARUPUDI	3821.66	397	40	432
8	PEDANA	8173.63	291.3	57.1	280
9	PAMARRU	830.26	1183.3	8.5	644
10	PEDAMADDALI	6301.61	178.9	5.9	196
11	GUDURU	1162.7	21.36	0.66	1124.7
12	MOPIDEVI	6285.9	17.08	0.27	536
13	CHALLAPALLI	4513	427.3	81.9	586.97
14	GHANTASALA	5168.58	478.8	27.1	886.56
15	ENDAKUDURU	64527.49	592.1	11.2	512
16	MOVVA	3728.92	596.6	20.6	944.76
17	PALANKIPADU	10403.08	759.1	322.2	854.17
18	KAZA	16579.5	432.6	18.3	648.9
19	NIDUMOLU	1122.83	339.1	91.2	631.143
20	PAMIDIMUKKALA	3124.92	165.4	0.91	798.62
21	THADANKI	13235.29	14.8	12.2	510.19
22	MEDURU	8398.98	86.7	11.9	857
23	MARRIVADA	2695	141.7	4.4	645.25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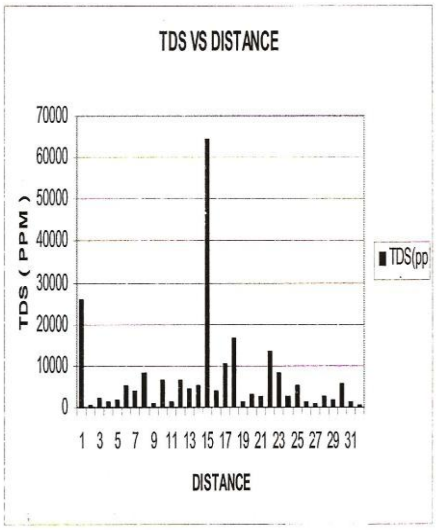
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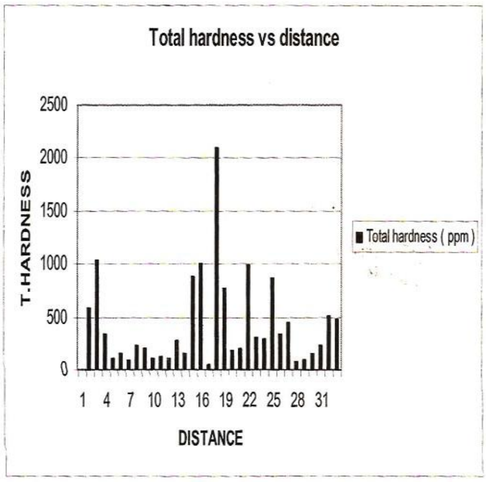
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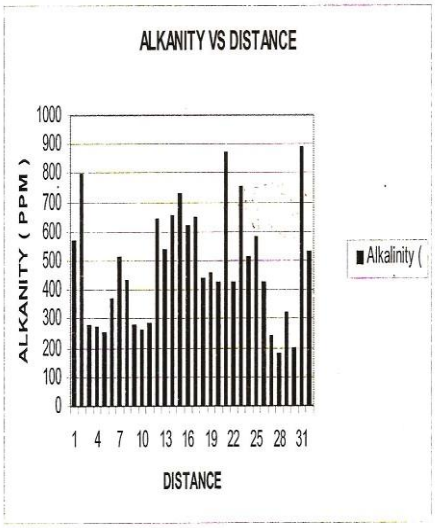
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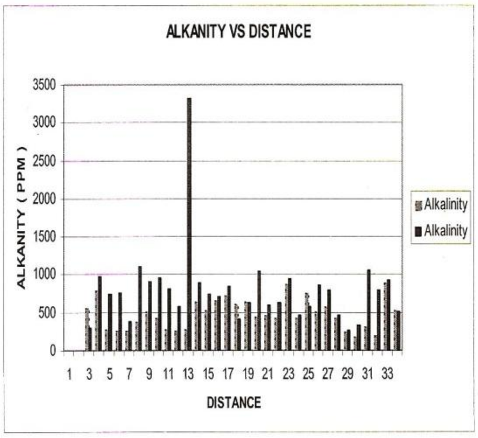

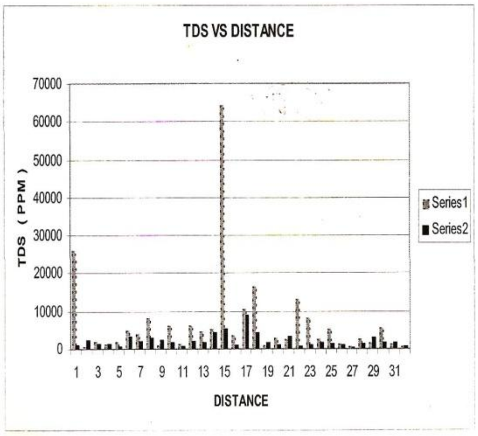

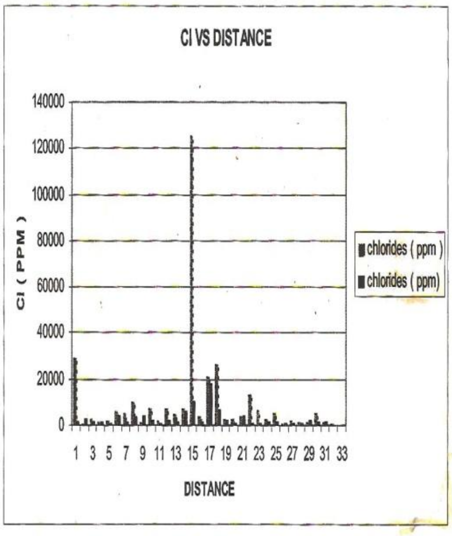

VI - ANALYSIS FOR KRISHNA DISTRICT

In the interpretation of January – 2010 results with January – 2011 results of Krishna district, unearthed interesting information and thoughts. Whereas interpretation says that alkalinity went on had a slump. However, in the case of hardness Machilipatnam, Koduru had tremendous hike, than the previous, but that is not scary because these two villages were situated near the seacoast, so seawater intrusion from the coastal line in most common.

Eve Marrivada had a tremendous hike in hardness than earlier, even located 40km away from the seacoast. This hike in value may be due to excess exploitation of ground water in that region for the sake of sugar cane crops or due to upward leakage from the underlying shallow artesian aquifer, or due to the presence of saline water in the under lying artesian aquifer.

We can observe tremendous hike in chlorides in Endrakoduru, Thadanki, and Mopidevi. But on interpolating with January – 2010 values, analysis says that chlorides are more whatever the year may be for Thadanki, this itself proves the presence of salt domes in the geological formations beneath the ground for Thadanki.

Whereas Endrakonduru had only one well surveying in the entire village so it says that entire village is dependent on that well for residential and commercial activities, which implies that excess pumping of water from wells is under execution. Even for Mopidevi. But, sugar cane crop is the heart of their agriculture, which reveals excess exploitation of water from bore wells.

When distance comes to criteria there were two villages located side-by-side Thadanki and Mantada. Water in Thadanki is relatively fresher when compared to water in Mantada i.e. water in Mantada is saline (hardness) that that in Thadanki, It may be due to the presence of perched aquifer beneath Thadanki or due to ground water recharging. That is, lakes were maintained in Thadanki, which are indirectly responsible for the ground water recharge.

Whereas if you consider TDS (ppm) hike in values for Palankipadu, Endrakuduru, Thadanki appears, as said earlier cat fishes were grown in the lakes in those villages i.e. aquaculture business on great demand in those regions. so ground water in those regions gets recharged as well as TDS also gets increased due to the aquaculture may be due to the remains of fish food, excreta of fishes, remains of fish, formation of organic matter, responsible for the hike in TDS those regions.

VII - CONCLUSIONS AND METHODS TO COMBAT SALT WATER INTRUSION

The increased use of groundwater and inadequate rainfall has caused the saltwater interface to coastal regions like Krishna delta.A good knowledge of aquifers (subsoil) enables scientists to determine the 'criticaldischarge', i.e. the extent to what aquifers can support water catchments withoutseawater intrusion taking place. Experts in hydrogeology acknowledge that such is a complex question, but they can currently give advice on prevention and control of situations caused by human activity.

Methods like recharge wells, recharge basins, and barrier wells have proven to be very useful in maintaining the proper equilibrium between ground water recharge and pumping. Proper groundwater monitoring techniques, groundwater management, combined with groundwater conservation are needed to keep salt-water intrusion under control.

Artificial Recharge:

Rising ground water heads by artificial recharges another effective technique. For confined aquifers, recharge wells are needed. This method requires development of a supplementary fresh water source.

Hydraulic Barriers

Pumping Barrier

Maintaining a continuous pumping through pumping a line of wells, located parallel to the coast creates a barrier for the intruding salt water. Seawater flows inland from the ocean to the trough and fresh water with in the aquifer flows seaward towards the trough.

Injection Barrier

Here, maintaining a pressure ridge parallel to the coast by a line of recharge wells creates an effective barrier. Here, the injected fresh water flows both seaward and landward.

Pumping – Injection Barrier

Combination of pumping and injection barrier system rises pumping-injection barrier system. Disadvantage of this system was that high cost of operation.

Physical Barrier

Construction of an impermeable or semi-pervious subsurface barrier extending Parallel to the coast through the thickness of the aquifer prevents the inflow of salt water. Such a barrier can be built in unconsolidated materials with sheet piles or filling up deep Trenches with clay, cement concrete or asphalt. The extent of control over intrusion relies on the location, depth permeability of the barrier. The costs involved may be very high and only small penetrations may be attained. Prior to adopting any of the control or remedial measures described above, the effectiveness of a particular method for a given coastal scenario can be evaluated by carrying appropriate simulation studies using a suitable numerical model.

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