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Models Study for Economical and Social Consequence of the Deterioration of Groundwater Quality by Domestic and Industrial Products

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Abstract: Correct in order on the form and trends of groundwater quality and quantity is obligatory as a origin for cost-effective and public progress and for protection of ecological value. The Ground water samples were collected from 35 locations in Ranipet, Vellore district, TamilNadu was assessed in the Monsoon during 2012. Water quality assessment was carried out for the parameters like pH, Electrical conductivity , Total dissolved solids , Total alkalinity , Total hardness ,Chloride, Sulphate, Calcium, Magnesium, Sodium, Potassium, Nitrate, Chromium, Phosphate, Iron. Water Quality Index and Correlation coefficients were determined to identify the highly correlated and interrelated water quality parameters (WQPs). Regression equations relating these identified and correlated parameters were formulated for highly correlated WQPs. Comparison of observed and estimated values of the different WQPs parameters reveals that the regression equations developed in the study can be very well used for making water quality monitoring by observing the above said parameters alone. The result of analysis have been used to suggest model for predicting water quality, The analysis reveals that the ground water of the area needs some degree of treatment before consumption, and it also need to be protected from the perils of contamination.
Keywords: Groundwater, Physico-Chemical Parameters, Monsoon Season, WQI, Correlation and Regression Analysis.

Introduction

Water being a universal solvent has been and is being utilized by mankind time and now. Of the total amount of global water, only 2.4% is distributed on the main land, of which only a small portion can be utilized as fresh water. The available fresh water to man is hardly 0.3-0.5% of the total water available on the earth and therefore, its judicious use is imperative. The fresh water is a finite and limited resource. The utilization of water from ages has led to its over development fixed with the growing population along with improved standard of living as a consequence of technological innovations[1]. This contamination of groundwater is not away from the evils of renewal Therefore, quality of groundwater is deteriorating at a faster pace due to pollution ranging from septic tanks, land fill leachates, domestic sewage agricultural runoff/ agricultural fields and industrial wastes[2]. Contamination of groundwater also depends on the geology of the area and it is rapid in hard rock areas especially in lime stone regions where extensive cavern systems are below the water table. This is a feature common, not only in developed countries but also in developing countries like India. The changes in quality of groundwater response to variation in physical, chemical and biological environments through which it passes[3]. The main objectives are to develop a WQI of the study area and Regression model for assessment of groundwater parameter.

Materials and Methods: Study Area:

The study area is located in North of TamilNadu in India and lies between Latitude N 12°52′30’’ – 12°57′30’’ and Longitude E 79°15’00’’–79°25′00’’, covering about 154.52 Sq.Km area. The area includes Ranipet, Walajapet, Arcot and Melvishram. The drainage of the study area is mainly Palar River and Ponnai River. The Ranipet area is a chronic polluted area and one of the biggest exporting centers of tanned leather. Many small-scale tanneries are processing leather in the study area and discharging their effluents on the open land and surrounding water bodies[4]. The total numbers of tannery industrial units located in and around this town are 240 besides other industries like ceramic, refractory, boiler auxiliaries plant, and chromium chemicals. Industries located in Ranipet are discharging effluents into Puliathengal, Vanapadi, and Thandalam lakes and it is a matter of increasing concern, as these industries are located in Palar river basin. Studies of groundwater also indicated the high concentrations of chromium in Palar river basin, which is much more than the permissible limit in drinking water. These tanneries are polluting the Palar River, causing ecological degradation and health hazards. Geologically the study area is covered by crystalline rocks of Archaean age consisting of Granites and some basic intrusive bodies. The alluvium consisting of fine to coarse sand and clay occurring in the area is of a fluviatile origin and restricted to the course of Palar river and major streams.

Methodology:

Sample Collection And Processing:

The assessment of groundwater quality, 35 Water samples from the selected sites were collected during July 2012 - May 2013 Shown in figure 1 and taken in pre-cleaned polyethylene bottles; the samples after collection were immediately placed in dark boxes and processed within 6 h of collection. The collected samples were analyzed for major physical and chemical water quality parameters like pH, EC, TDS, TA, Total hardness, chloride, sulphate, calcium, magnesium, sodium, potassium, Chromium, Iron, and Nitrate as per the method. Assessment of Ground Water Quality described in “Standard methods for the examination of water and wastewater American Public Health Association[5]. The parameters present in the water sample can be calculated by using various methods. In the present study, the fourteen parameters were considered and the WQI and correlation coefficients among all these water quality characteristics were calculated. The linear regression equation was developed for the pairs having strong correlation and also for the pair of parameters, which have influence on each other. The correlation analysis on water quality parameters revealed that all parameters were more or less correlated with each other[6]. The characteristics were calculated using the regression equations and then compared with the observed values.

Water Quality Index:

Water quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption. Water quality and its suitability for drinking purpose can be examined by determining its quality index.

Fig. 1: Location of well sampling stations of the study area

Table . 1 Normal Statistics of Water Quality parameters of Groundwater Samples

Statistics for monsoon season														
WQPs	**pH**	**TDS**	**EC**	**TH**	**Ca**	**Mg**	**NO_3**	**Cl**	**F**	**Na**	**K**	**Iron**	**SO_4**	**Cr**
Minimum	7.0	362.0	516.0	212.0	48.0	22.0	2.0	42.0	0.3	28.0	4.0	0.1	29.0	0.0
Maximum	7.4	4232.0	6046.0	1200.0	320.0	96.0	70.0	1609.0	0.9	790.0	50.0	0.5	486.0	0.0
Mean	7.2	1838.9	2626.9	487.8	117.9	46.0	29.4	507.5	0.5	358.9	25.6	0.3	219.5	0.0
Std. Deviation	0.1	910.1	1300.0	223.1	64.4	17.0	21.6	340.2	0.2	187.3	12.1	0.1	102.7	0.0
Variance	0.0	828228.9	1689879.4	49773.3	4144.3	288.1	464.9	115728.1	0.0	35073.5	146.5	0.0	10538.5	0.0

The standards for drinking purpose have been considered for calculation of WQI. In this method the weight age for various water quality parameters is assumed to be inversely proportional to the recommended standards for the corresponding parameters. The WQI has been calculated to evaluate the suitability of groundwater quality of the study area for drinking purposes. The WHO (2004) standards for drinking purpose have been considered for the calculation of WQI[7]. For the calculation of WQI, Fourteen parameters such as: pH, EC, TDS, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Iron, Sulphates, Chlorides, Fluorides, Nitrates and Chromium) have been used.

Table 2. WHO standards weight (w_i) and calculated relative weight (W_i) for each parameter.

Parameters	**Standard Permissible Value (SI) (WHO, 2004)**	**Weight (w_i)**	**Relative Weight (W_i)**
pH	6.5 - 8.5	4	0.09
TDS	500	4	0.09
EC	500	4	0.09
Th	200	3	0.06
Ca	75	2	0.04
Mg	50	1	0.02
Nitrate	45	5	0.11
Chloride	250	3	0.06
Flouride	1-1.5	4	0.09
Sodium	200	2	0.04
Potassium	200	2	0.04
Iron	1	4	0.09
Sulphate	250	4	0.09
Chromium	0.05	5	0.11
Total		**47**	**1.00**

Result and Discussion:

The statistical evaluations from physico - chemical data for the groundwater of the study area in monsoon season during the entire study period are summarized in Table No.1. In Monsoon season, the pH values of all 35 samples were in the range 7.0 – 7.4 with the mean value 7.2. Total Suspended Solids were detected in the range 362 – 4232 mg/l with the mean value of 1838.9 mg/l. Electrical Conductivity varied in the range 516 – 604 µmho/cm with mean value 2626.9 µmho/cm. Total Hardness were observed in the range 212 – 1200 mg/l with mean value of 487.8 mg/l. Calcium and Magnesium contents were found in the range 48 – 320 and 22 – 96 mg/l and with their mean values are 117.9 and 46mg/l respectively[8]. Nitrate concentration varied in the range 2 -70 mg/l with mean value 29.4 mg/l. Chloride and Fluoride level were observed in the range 42 – 1609 mg/l and 0.3 – 0.9 mg/l with the mean values were 507.5 and 0.5 mg/l respectively. Sodium and Potassium contents were found in the range 28 – 790 and 4 – 50 mg/l with mean values were 358.9 and 25.6 mg/l respectively. Iron and Chromium content were found in the range 0.1 – 0.5 and 0.001-0.002 with their mean values 0.3 and 0.015 respectively. Sulphate concentrations were observed in the range 29 – 486 mg/l with mean value 219.5 mg/l respectively[9].

Table.No. 3 Water Quality Index Values for collected groundwater samples

Well No.	WQI for Monsoon Season	Status	Well No.	WQI for Monsoon Season	Status	Well No.	WQI for Monsoon Season	Status
1	120.62	Poor	13	116.01	Poor		123.45	Poor
2	169.97	Poor	14	129.62	Poor	26	96.28	Good
3	48.69	Excellent	15	211.02	Very poor	27	146.11	Poor
4	105.40	Poor	16	335.20	unfit for use	28	108.37	Poor
5	126.93	Poor	17	83.70	Good	29	63.88	Good
6	293.01	Very poor	18	179.26	Poor	30	140.40	Poor
7	240.96	Very poor	19	254.11	Very poor	31	91.61	Good
8	211.87	Very poor	20	203.82	Very poor	32	92.14	Good
9	211.97	Very poor	21	108.95	Poor	33	89.33	Good
10	115.58	Poor	22	174.99	Poor	34	190.51	Poor
11	99.97	Good	23	148.36	Poor	35	104.69	Poor
12	121.95	Poor	24	245.23	Very poor			

The water quality rating analysis reveals that 9% of samples were found as excellent water in monsoon season may be due to increased rate of weathering and seepage of manmade pollutants[10]. 26% samples were poor in monsoon as shown in table 4. It indicates that the ground water quality in the study area is slowly getting to degradation.

Table 4 : Water Quality Classification Based on WQI Values of the Study Area

Water Quality	WQI Values	WQI Of samples for Monsoon	% of water samples (Monsoon)
Excellent water	<50	48.69	**9%**
Good water	50-100	88.12	**17%**
Poor water	100-200	135.06	**26%**
Very poor water	200-300	245.24	**48%**
unfit for use	>300	-	-

The relationship between two variables is the correlation coefficient which shows how one variable predicts the other. Associated with correlation coefficient is r, which is the percentage of variance in the dependent variable, explained by the independent variable. The results of the correlation analysis are considered in the subsequent interpretation[11]. A high correlation coefficient (nearly 1 or -1) means a good relationship between two variables, and a correlation coefficient around zero means no relationship. Positive values indicate a positive relationship while negative values of r indicate an inverse relationship. The correlation coefficients (r) among various water quality parameters of ground water of the study area in monsoon season were calculated and the values of correlation coefficients (r) are given in Table 5 and 6 respectively.

Table – 5 Correlation matrices for water quality parameters during Monsoon season

WQPs	pH	TDS	EC	TH	Ca	Mg	NO_3	Cl	F	Na	K	Iron	SO_4	Cr
pH	1													
TDS	.250	1												
EC	.251	**1.000**	1											
TH	.231	**.959**	**.959**	1										
Ca	.228	**.941**	**.941**	**.988**	1									
Mg	.231	**.907**	**.907**	**.935**	**.872**	1								
No3	.057	.219	.219	.227	.254	.160	1							
Cl	.279	**.928**	**.928**	**.907**	**.873**	**.898**	.168	1						
F	.312	.410	.410	.352	.360	.299	-.072	.407	1					
Na	.239	**.988**	**.988**	**.917**	**.898**	**.868**	.228	**.897**	.393	1				
K	.261	**.841**	**.841**	.776	.742	.767	.252	.772	.238	**.859**	1			
Iron	.241	.289	.289	.303	.332	.193	.189	.314	.257	.305	.187	1		
SO_4	.029	**.844**	**.844**	**.857**	**.832**	**.826**	.180	**.860**	.173	**.827**	.696	.302	1	
Cr	-.254	-.321	-.321	-.318	-.320	-.297	.147	-.345	-.149	-.310	-.360	-.182	-.254	1

The results of the statistical analysis which are shown in table 5 (Monsoon season) gave an indication that TDS has positive and significant correlation with EC, TH, Ca, Mg, ,Cl^-, Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium. EC has a positive and signification correlation with TH, Ca, Mg, Cl^- , Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium. Total hardness has positive and signification correlation with Ca, Mg, Cl^-, Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium. Calcium has positive and signification correlation with Mg, Cl^-, Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium. Magnesium has positive and signification correlation with Cl^-, Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium[12]. Chloride has positive and signification correlation with Na, K and SO_4^{2-}, weak correlation with Nitrate and negative correlation with Chromium. Nitrate and Chromium are weakly correlated with most of the water quality parameters.

Table 6 Least Square of the Relation (Y = Ax + B) Among Significantly Correlated Parameters

Y (dependent)	X (Independent)	correlation	b	a	Regression Equation	R Square
MONSOON SEASON						
EC	TDS	1.000	0.099	1.428	EC = 1.428 TDS +0.099	1.000
EC	TH	0.959	-98.079	5.586	EC = 5.586 TH – 98.079	0.919
EC	Cl^-	0.928	826.993	3.547	EC = 3.547 Cl^- +826.993	0.861
EC	SO_4^{2-}	0.844	280.881	10.689	EC = 10.689 SO_4^{2-}+ 280.881	0.712
EC	Mg^{2+}	0.907	-570.628	69.467	EC = 69.467 Mg^{2+} - 570.628	0.823
EC	Na^{2+}	0.988	165.103	6.859	EC = 6.859 Na^{2+} + 165.103	0.976
TDS	TH	0.959	-68.922	3.911	TDS = 3.911 TH – 68.922	0.919
TDS	Cl^-	0.928	579.012	2.483	TDS = 2.483 Cl^- + 579.012	0.861
TDS	SO_4^{2-}	0.844	196.596	7.483	TDS = 7.483 SO_4^{2-} + 196.596	0.712
TDS	Ca^{2+}	0.941	269.311	13.308	TDS=13.308 Ca^{2+} +269.311	0.886
TDS	Mg^{2+}	0.907	-399.486	48.631	TDS=48.631 Mg^{2+} - 399.486	0.823
TH	SO_4^{2-}	0.857	79.140	1.862	TH=1.862 SO_4^{2-} +79.140	0.734
TH	Ca^{2+}	0.988	84.100	3.423	TH=3.423 Ca^{2+} + 84.100	0.975
TH	Mg^{2+}	0.935	-77.731	12.287	TH=12.287 Mg^{2+} - 77.731	0.874
Ca^{2+}	Mg^{2+}	0.872	-34.208	3.306	Ca^{2+}=3.306 Mg^{2+} - 34.208	0.760
Ca^{2+}	SO_4^{2-}	0.832	3.471	0.522	Ca^{2+}=0.522 SO_4^{2-} + 3.471	0.692
Ca^{2+}	TDS	0.941	-4.519	0.067	Ca^{2+}=0.067 TDS – 4.519	0.886
Mg^{2+}	SO_4^{2-}	0.826	16.046	0.137	Mg^{2+} =0.137 SO_4^{2-} + 16.046	0.683
Mg^{2+}	TDS	0.907	14.922	0.017	Mg^{2+}=0.017 TDS + 14.922	0.823
Na^{2+}	Cl^-	0.897	108.343	0.494	Na^{2+} =0.494 Cl^- + 108.343	0.804
K	Cl^-	0.772	11.663	0.027	K =0.027 Cl^- + 11.663	0.596
Cl^-	TDS	0.928	-130.454	0.347	Cl^-=0.347 TDS – 130.454	0.861
SO_4^{2-}	TDS	0.844	44.398	0.095	SO_4^{2-}=0.095 TDS + 44.398	0.712
Na^{2+}	TDS	0.988	-15.014	0.203	Na^{2+} =0.203 TDS – 15.014	0.976

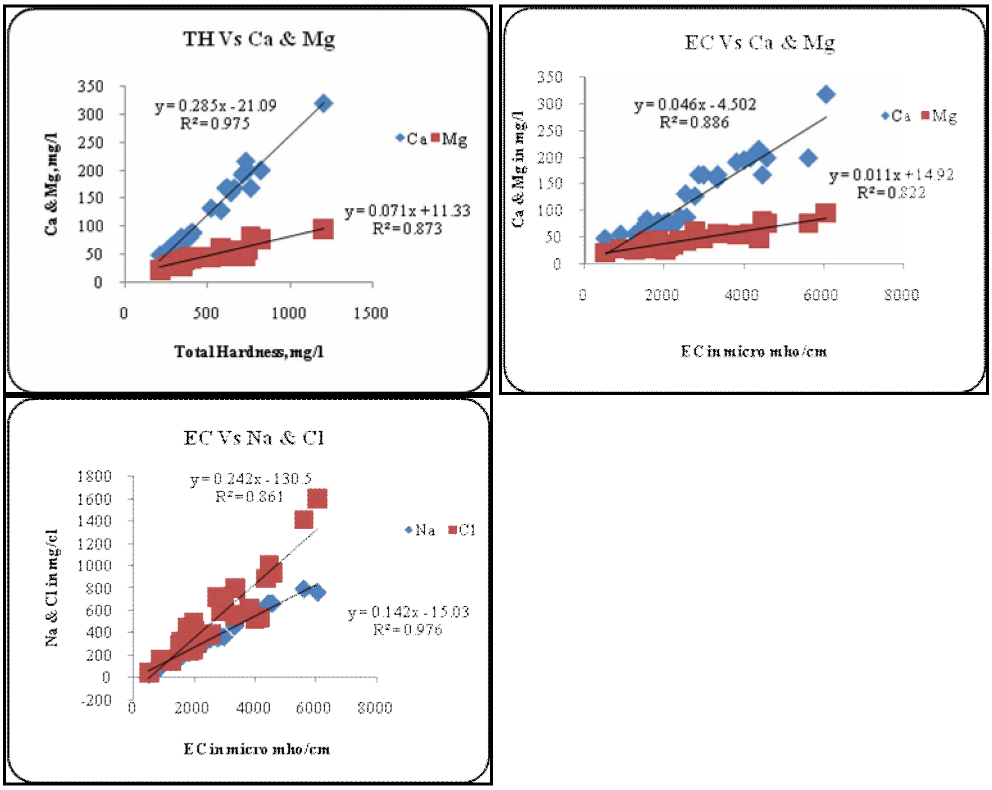

Fig : 2 Linear Plot between TH Vs Ca & Mg , EC Vs Ca & Mg and EC Vs Na & Cl of groundwater in Monsoon Season

Conclusion:

The analysis of experimental investigation on quality of groundwater using 14 physico-chemical parameters of the study area indicate that in general about the water quality was poor, very poor and unsuitable for drinking purpose. In this study, the computed WQI values ranges from **48.69 to 245.24** during monsoon period. The Percentage of water quality index shows that minimum in monsoon period. Results of correlation analysis show that EC, TH and TDS are having high correlation with most of the parameters for all the seasons. Since, the EC and TH find high correlation with the Ca and Mg, Na and Cl (fig 2) during Monsoon season. Regression equations relating the EC, TDS, TH and these parameters were formulated are given in Table 7. This indicates the increase in the pollution load due to the intrusion of domestic sewage and industrial effluents into the Groundwater. Hence, consistent monitoring measures are very important to assess the impact of the percolation of the wastewater, causing contamination of the groundwater in the study area, and a preventive mechanism coupled with remedial measures is necessary for the benefit of mankind. It is also recommended that water analysis should be carried out from time to time to monitor the rate and kind of pollution. It is need of human to expand awareness among the people to maintain the cleanness of water at their highest quality and purity levels to achieve a healthy life.

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