INFLUENCE OF SALINITY AND THE RELATION AMONG ITS PARAMETERS -A CASE STUDY OF PERIYAR RIVER ESTUARIES

M.M.Prabhakaran[1], G.Resmi[2]

[1]*Research Scholar, CED, Karpagam University, Coimbatore, (India)*

[2]*Associate Professor, CED, NSS College of Engineering, Palakkad, (India)*

ABSTRACT

Periyar River source of Kochi water supply scheme has become contaminated by varying degrees of salinity due to saltwater intrusion from rising sea level and upstream withdrawal of freshwater. Chloride in the form of negative ion is one of the major inorganic anions in saltwater and freshwater. Conductivity in water is affected by the presence of inorganic dissolved solids including chloride, nitrate, sulphate, and phosphates. Total Dissolved Solids refers to the amount of organic and inorganic dissolved substances found in water as in the form of salts too. It will be more useful of a general relationship with the parameters of Chloride, Electrical Conductivity and Total Dissolved Solids for any works related to the salinity concentration, anywhere in estuary. As the parameters considered in the study have pivotal role in governing the quality of river water and thereby to fix the purpose or to treat the water up to the standards for the purpose. Through the relationship obtained, concentration of other two parameters can be computed using the measured status of one of the three parameters. Minimizing time to estimate how drinking water source is affected by salinity is an important application of this relationship.

Keywords: Chloride, Drinking Water, Electrical Conductivity, River Source, Salinity, Total Dissolved Solids

I. INTRODUCTION

1.1 Surface Source

Periyar River is the source of water supply to Kochi city and adjoining area. Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates [14]. These factors affect the proportion of water loss. All these factors are considered in the study of Periyar River also.

Human activities make large and devastating impact on these factors such as increase in the storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing stream flow [14]. Bhuthathankettu is a downstream reservoir in Periyar River has a pivotal role in controlling the flow in the river especially during its lean flow period.

The total quantity of water available at any given time is an important consideration. Some users have an intermittent need for water. Many Irrigation projects require large quantities of water in the summer, and no water at all in the monsoon. To supply such an organisation with water, a surface water system may require a large storage capacity to collect water throughout the year and release it in a short period of time. Other users have a continuous need for water, such as Kerala Water Authority and industries that requires water for drinking and Industrial purposes. To supply such an organisation with water, a surface water system only needs enough storage capacity to fill in when average stream flow is below the organizations need.

It is estimated that an average rainfall of 3000mm is expected to the water sheds of Periyar River [14].The natural surface water can be augmented by importing surface water from another watershed through the naturally formed canals [14]. Various contributions reaching a river through the runoff and also from various industries may change the river characteristics, and class of a river.

1.2 Water Quality

Quality of water is crucial for maintaining a healthy environment and providing drinking water for communities. It assists agricultural enterprises to be productive and profitable and is important for many recreational activities. The quality of water required depends on its purpose – for example, water that is suitable for gardening may not be suitable for drinking.

Water quality determines the 'goodness' of water for particular purposes. Water quality tests will give information about the health of the waterway. By testing water over a period of time, the changes in the quality of the water can be seen.

Many water quality variables are subject to large fluctuations in space and time. Understanding these fluctuations in the physical environment and determining whether such changes are natural or a result of anthropogenic influences can be a difficult problem. An ideal variable provides unambiguous information about the condition of the environment in relation to reference conditions and is relatively easy and inexpensive to measure. In general, several studies revealed that parameters include temperature, pH, turbidity, salinity, nitrates and phosphates are to be tested to assess the health of water [15].

About the prevention of saltwater intrusion, the reports reveal that during the course of flow the river can be replenished through small water ways which connect with the main water way. This replenished water can effectively restrict the salinity intrusion [12]. Another study says that the extent of salinity intrusion depends on the balance between fresh water discharges and saltwater from the sea [13].

The study about Mandovi says that large changes in the salinity distribution occur from the ocean point to the upstream regions annually. The heavy rainfall and associated river discharge during the SW-monsoon limit the salinity distribution to the first 12 km from the ocean point of estuary and this stretch is fully stratified during the above period. The remaining upstream regions become fully fresh water [1]. It is reported that the length of the saltwater intrusion is determined by the freshwater discharge rate, whereas the shape of saltwater wedge is determined by many variables, such as the freshwater discharge and topographic shape of the estuary [2].

In this paper an attempt is made to study how salinity affects drinking water quality. Also the various parameters contributing to salinity levels are analysed and measured.

II. LITERATURE REVIEW

2.1 Salinity

Salinity is a measure of the dissolved salts in the water. Salinity is usually highest during periods of low flows and increases as water levels decrease. Salinity is measured as either TDS (Total Dissolved Solids), which measures the amount of dissolved salts in the water, or as EC (Electrical Conductivity), which is the property of a substance which enables it to serve as a channel or medium for electricity. Salty water conducts electricity more readily than purer water. Water containing a TDS level of over 500 mg/l tastes unpleasant to drink [9].

Salinity is the total of all non-carbonate salts dissolved in water, usually expressed in parts per million (ppm). Salinity is considered as a measure of the total salt concentration, comprised mostly of Na^+ and Cl^- ions. Even though there are smaller quantities of other ions in seawater (e.g., K^+, Mg^{2+}, or SO_4^{2-}), sodium and chloride ions represent about 91% of all seawater ions. Salinity is an important measurement in seawater or in estuaries where freshwater from rivers and streams mixes with salty ocean water. The salinity level in seawater is fairly constant, at about 35 ppt (35,000 mg/l), while brackish estuaries may have salinity levels between 1 and 10000 ppm. Since most anions in seawater or brackish water are chloride ions, salinity can be determined from chloride concentration [12].

Salinity can also be measured in freshwater. Compared to seawater or brackish water, freshwater has much lower levels of "salt ions" such as Na^+ and Cl^-; in fact, these ions are often lower in concentration than hard-water ions such calcium (Ca^{2+}) and bicarbonate (HCO_3^-). Because salinity readings in freshwater will be significantly lower than in seawater or brackish water, readings are often expressed in mg/l instead of ppt (1 ppt = 1000 mg/l) [12].

2.2 Expected Levels

Seawater has a chloride ion concentration of about 19,400 mg/L (a salinity of 35.0 ppt). Brackish water in tidal estuaries may have chloride levels between 500 and 5,000 mg/L (salinity of 1 to 10 ppt). Freshwater streams and lakes have a significant chloride level that can range from 1 to 250 mg/L (salinity of 1 to 500 ppm) [12].

2.3 Chloride and Salinity

Chloride, in the form of the Cl^- ion, is one of the major inorganic anions, or negative ions, in saltwater and freshwater. It originates from the dissociation of salts, such as sodium chloride or calcium chloride, in water.

$$NaCl(s) \longrightarrow Na^+(aq) + Cl^-(aq)$$

$$CaCl_2(s) \longrightarrow Ca^{2+}(aq) + 2\ Cl^-(aq)$$

These salts, and their resulting chloride ions, originate from natural minerals, saltwater intrusion into estuaries, and industrial pollution.

Because salinity is directly proportional to the amount of chlorine in sea water, and because chlorine can be measured accurately by a simple chemical analysis, salinity 'S'was redefined using chlorinity, S = 0.03 + 1.805Cl where chlorinity Cl is defined as" the mass of silver required to precipitate completely the halogens in 0.328 523 4kg of the sea-water sample [10].In drinking water, the salty taste produced by chloride depends upon the concentration of the chloride ion. Water containing 250 mg/L of chloride may have a detectable salty taste if the chloride came from sodium chloride. As per Indian standards, the maximum permissible level of chloride in drinking water is limited to 250mg/l [11].

2.4 Conductivity and Salinity

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminium cations. Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius [3].

The basic unit of measurement of conductivity is the mho or Siemens. Conductivity is measured in micromhos per centimetre (µmhos/cm) or microsiemens per centimetre (µs/cm). Distilled water has conductivity in the range of 0.5 to 3 µmhos/cm. The conductivity of most of the rivers generally ranges from 50 to 1500 µmhos/cm [3].

The relation between Electrical Conductivity's and total salt content of soils was established using a regression analysis [4].

2.5 TDS and Salinity

TDS, which stands for Total Dissolved Solids, refers to the amount of organic and inorganic dissolved substances that may be found in water, such as minerals, metals and salts. Essentially, it is everything present in water other than pure H_2O and suspended solids. TDS can be from natural sources such as dissolved rock or from man-made chemicals such as Volatile Organic Chemicals (VOC's) [3].

Often, a major component of TDS is hard and soft minerals. Because water is naturally slightly acidic, as it travels through the rock formations in the ground a small quantity of rock is dissolved into a liquid form. These dissolved minerals include calcium, magnesium, chlorides and silica.

Total Dissolved Solids are measured as milligram per litre, and it is worth noting that Central Public Health and Environmental Engineering Organisation's drinking water standards recommend a limit of 500 mg/lit. It is also worth noting that the national average is probably in the range 300-350 mg/lit for India. The lower the TDS, the more pure the water is [3].

III. METHODOLOGY

3.1 Chloride Concentration and Salinity

A Chloride Ion-Selective Electrode is used to measure the chloride ion concentration in the water (in mg/L) either on site or after returning to the lab. Salinity can be determined using the relationship, salinity in mg /L = 1.8066 5 Cl^- (mg/L).

3.2 Conductivity and Salinity

A Conductivity Meter is used to measure the salinity value of the water (in ppt). If salinity values exceed 13000 ppm, dilution of samples will be necessary. This method uses the assumption that most of the ions in the solution are non-carbonate salt ions (e.g., Na^+, K^+, or Cl^-), and converts the conductivity reading to a salinity value. The conductivity of Periyar river at Aluva is measured as 1100 µS/cm.

3.3 TDS and Salinity

No exact relationship is derived between conductivity as µS/cm and TDS as ppm. An approximate relationship obtained shows that, TDS of water with a higher proportion of Sodium Chloride in ppm = 0.5 X conductivity as µS/cm [3].

3.4 Relationship between Chloride, Conductivity and TDS

The conductivity of sea water is around 54000µS/cm. Then the TDS value is approximately 35000ppm. Seawater has a high proportion of sodium chloride and this is around 28000 ppm. Any works related to the salinity concentration, using the parameters in any place whether it is in estuary, or in brackish water or in deep sea, the above relationship can be considered as a guideline for modelling studies suiting to the situation[3].

3.5 Method of Study

In the present study, the intake point in Periyar River for Kochi Water Supply Scheme is considered. The periodical sampling studies were conducted on the mentioned parameters such as Chloride, Electrical Conductivity and TDS. The test results were analysed and tabulated along with the measured values of salinity concentration. The change in salinity concentration with respect to the flow variation also studied for different years with extreme conditions [5]. Based on the salinity concentration, the appropriate factors for the respective parameters suit to the Estuary of Periyar River is worked out. The plotted graph using the developed factors will give a relation between the flow and salinity [6], and there by the concentration of Chloride, Electrical Conductivity and TDS can be evaluated immediately without any additional labour and materials.

IV. RESULTS AND DISCUSSION

4.1 Study Area

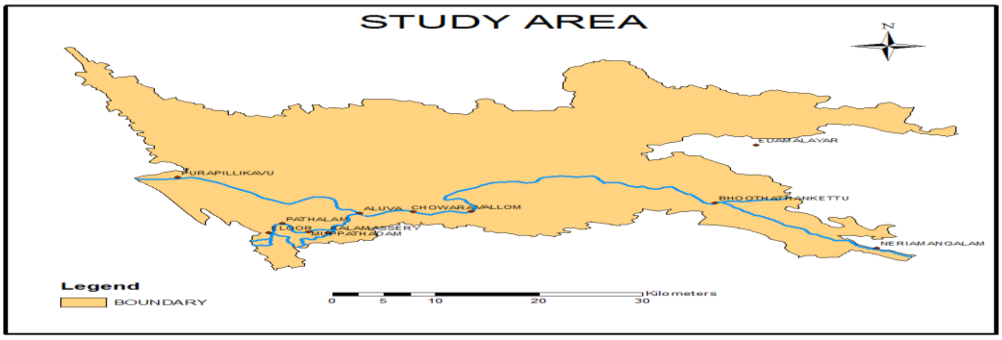

Fig. 1 Catchment area of the River stretch under study

Periyar River Basin - Study Area: 1990.10 Km sq, Length of river for the study: 78 Km is a part of Kerala lies between North latitudes $10^{0}5^{'}$ –10^{0} $2^{'}$ and, East longitudes 76^{0} 49'- 76^{0} $16^{'}$.

Bhoothathankettu releases the flow downstream along the river. Later it bifurcates into two and meets with sea at Purapillikavu and Eloor (distance covered from Aluva to Purappillikkavu 20.74 kms and that from Aluva to Eloor is 4.04km.

4.2 Salinity Relationship between Chloride, Conductivity and TDS

To derive the relationship between Chloride, Electrical Conductivity and Total Dissolved Solids, with the salinity, the relationship between an individual parameter and salinity obtained and found that the mentioned values are suitable for correlating the parameters [7].

To assess the salinity through Electrical Conductivity, total Dissolved solids and Chloride, water sample analysis were carried out as per standard methods and the values of each parameter in every month was recorded. The salinity contributed or measured through each parameter for the corresponding month was computed and tabulated from 2009 to 2012.

Table: 1 Relations between Salinity Contributing Parameters

Standardization Works			
Conductivity in µmho/cm	54000	Ratio Cond. to TDS	1.542857143
TDS in mg/l	35000	Ratio Cond. to Cl^-	1.928571429
Chloride in mg/l	28000	Ratio TDS To Cl^-	1.25
Salinity in mg/l	50584.8	Cl^- to Salinity	1.8066
TDS to Salinity	1.44528	Cond. to Salinity	0.936755556

4.3 Relationship between Flow and Salinity due to Chloride, Conductivity and TDS

To obtain the relation between the flow and salinity the flow, Chloride, Electrical Conductivity and Total Dissolved Solids at Aluva have been measured and tabulated. Further, using the relationship vide Para (4.2), the salinity contributed through Chloride, Electrical Conductivity and Total Dissolved Solids are computed. A graph for the year 2009 is also plotted, which reveal the relationship of the salinity measurement between the selected three parameters and its relation with the flow.

The graph depicts the strong relationship between the computed the salinity values through Chloride, Electrical Conductivity and the Total Dissolved Solids during the year 2009.

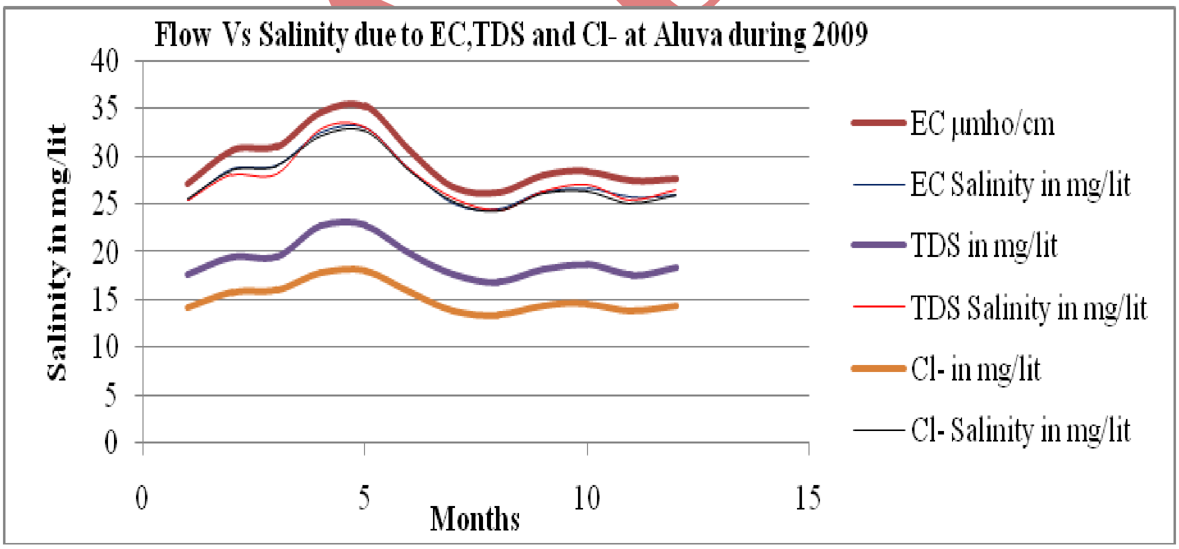

Fig. 2 Relationship between the Salinity contribution and corresponding Parameters

Tables 2, 3, 4 and 5 show the computed values of Electrical Conductivity, Total Dissolved Solids and Chloride for the years 2009, 2010, 2010 and 2012.

Table: 2 Salinity at Aluva Based on EC, TDS and Cl⁻ during 2009

Month	EC µmho/cm	EC Salinity in mg/lit	TDS in mg/lit	TDS Salinity in mg/lit	Cl^- in mg/lit	Cl^- Salinity in mg/lit
January	27.18	25.46	17.57	25.39	14.14	25.55
February	30.58	28.65	19.43	28.08	15.79	28.53
March	31.01	29.05	19.51	28.20	16.04	28.98
April	34.65	32.46	22.70	32.81	17.76	32.09
May	35.23	33.00	22.83	33.00	18.04	32.59
June	30.56	28.63	19.83	28.66	15.78	28.51
July	26.72	25.03	17.73	25.63	13.91	25.13
August	26.19	24.53	16.84	24.34	13.42	24.24
September	27.98	26.21	18.18	26.28	14.43	26.07
October	28.39	26.60	18.71	27.04	14.58	26.34
November	27.46	25.72	17.56	25.38	13.89	25.09
December	27.59	25.85	18.35	26.52	14.34	25.91

Table: 3 Salinity at Aluva Based on EC, TDS and Cl⁻ during 2010

Month	EC µmho/cm	EC Salinity in mg/lit	TDS in mg/lit	TD Salinity in mg/lit	Cl^- in mg/lit	Cl^- Salinity in mg/lit
January	28.67	26.86	18.49	26.72	14.76	26.67
February	32.12	30.09	21.25	30.71	17.07	30.84
March	54.90	51.43	35.90	51.89	28.42	51.34
April	51.86	48.58	32.86	47.49	26.44	47.77
May	64.16	60.11	41.16	59.49	32.87	59.38
June	36.67	34.35	23.56	34.05	18.67	33.73
July	33.87	31.73	22.16	32.03	17.64	31.87
August	34.94	32.73	22.74	32.87	18.01	32.54
September	38.42	35.99	24.76	35.79	19.76	35.70
October	30.08	28.18	19.28	27.87	15.30	27.64
November	32.71	30.64	21.35	30.86	16.89	30.51
December	32.96	30.88	21.68	31.33	16.94	30.60

Table: 4 Salinity at Aluva Based on EC, TDS and Cl^- during 2011

Month	EC µmho/cm	EC Salinity in mg/lit	TDS in mg/lit	TD Salinity in mg/lit	Cl^- in mg/lit	Cl^- Salinity in mg/lit
January	34.80	32.60	22.60	32.66	17.76	32.09
February	34.96	32.75	22.90	33.10	17.85	32.25
March	48.20	45.15	30.80	44.52	24.56	44.37
April	70.10	65.67	45.70	66.05	36.18	65.36
May	61.40	57.52	39.60	57.23	31.23	56.42
June	48.20	45.15	31.90	46.11	25.42	45.92
July	28.70	26.89	19.20	27.75	14.82	26.77
August	27.80	26.04	18.35	26.52	14.07	25.42
September	41.70	39.06	27.30	39.46	21.34	38.55
October	45.00	42.16	28.70	41.48	22.86	41.30
November	40.32	37.77	26.20	37.87	20.72	37.43
December	37.10	34.76	24.60	35.55	18.86	34.07

Table: 5 Salinity at Aluva Based on EC, TDS and Cl^- during 2012

Month	EC µmho/cm	EC Salinity in mg/lit	TDS in mg/lit	TD Salinity in mg/lit	Cl^- in mg/lit	Cl^- Salinity in mg/lit
January	37.60	35.22	24.47	35.37	19.47	35.17
February	38.12	35.71	24.96	36.07	19.85	35.86
March	61.80	57.89	40.10	57.96	31.65	57.18
April	59.60	55.83	38.46	55.59	30.48	55.07
May	54.30	50.87	35.10	50.73	28.02	50.62
June	31.80	29.79	20.59	29.76	16.42	29.67
July	28.40	26.61	18.42	26.62	14.62	26.42
August	29.80	27.92	19.86	28.70	15.40	27.83
September	37.10	34.76	23.96	34.63	18.96	34.25
October	37.90	35.50	24.22	35.01	19.24	34.76
November	51.30	48.06	33.10	47.84	26.45	47.78
December	41.60	38.97	26.90	38.88	21.16	38.23

A comparison of the computed values of salinity based on the three parameters Electrical Conductivity, Total Dissolved Solids and Chloride during 2009 to 2012 was carried out. The suitability and adaptability of these three parameters for computing the salinity in the estuaries of Periyar River can be well understood from the graphs plotted (Fig 2,3,4,5)

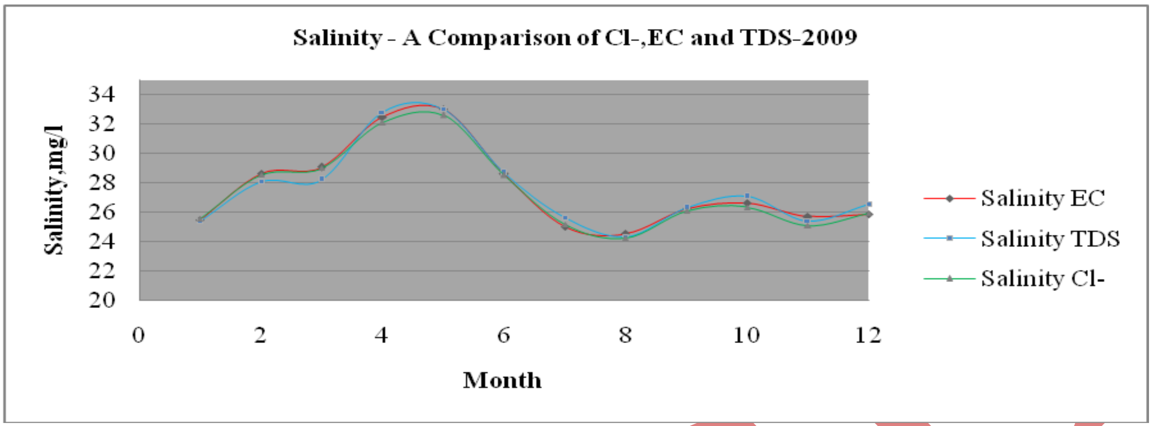

Fig. 3 Comparison of Salinity through Cl⁻, EC and TDS in 2009

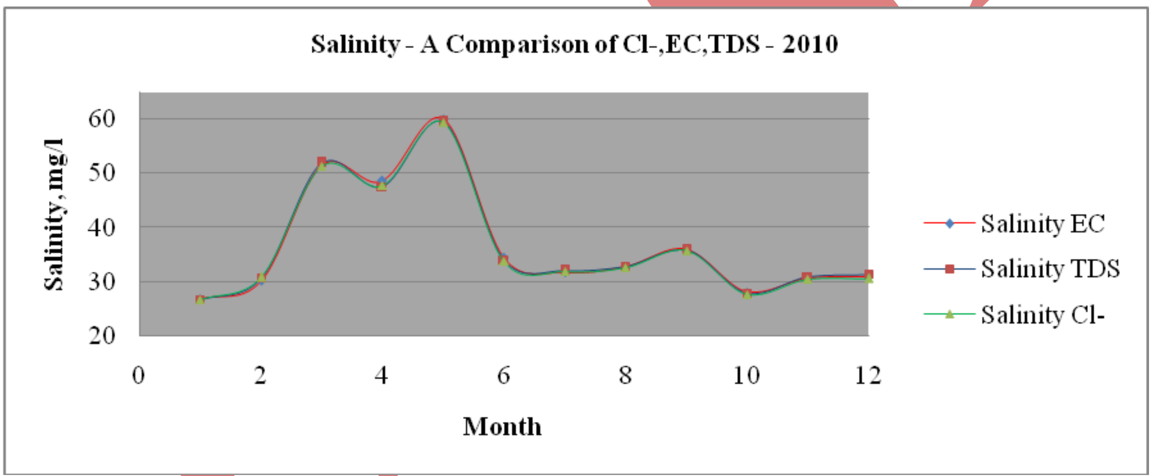

Fig. 4 Comparison of Salinity through Cl⁻, EC and TDS in 2010

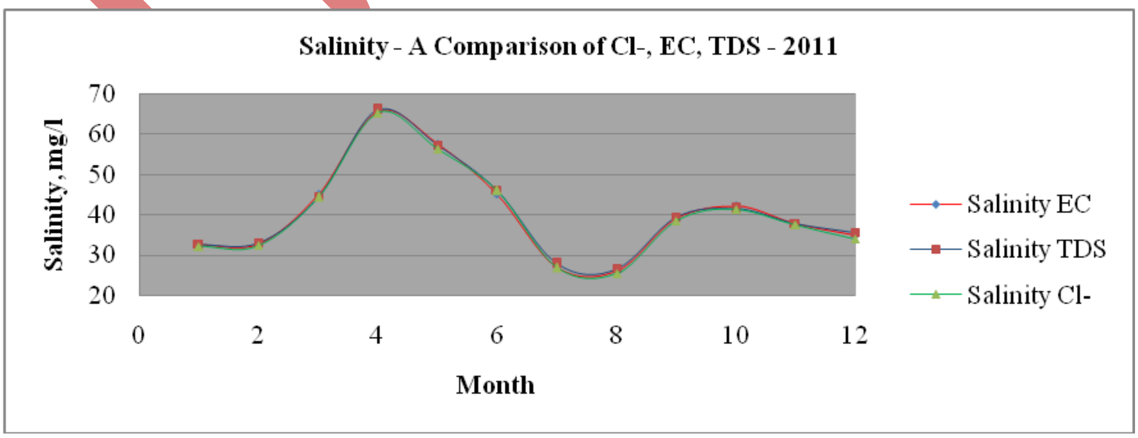

Fig. 5 Comparison of Salinity through Cl⁻, EC and TDS in 2011

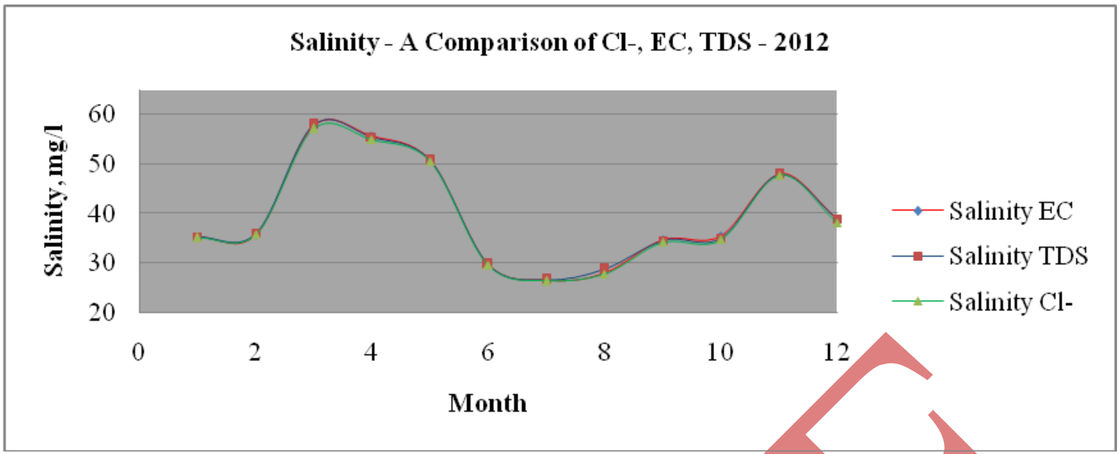

Fig. 6 Comparison of Salinity through Cl^-, EC and TDS in 2012

4.4 Verification of Validity

Regression analysis is a statistical technique that attempts to explore and model the relationship between two or more variables using a straight line described by the equation y = a +bx where 'b' is the slope of the line and 'a' is the intercept i.e. where the line cuts the y axis. In this study an attempt is made to know the relationship between the salinity obtained using three entirely different parameters. Because two variables are correlated that one variable is causing the other to behave a certain way [8].

Correlation coefficient is a statistical parameter, r, used to define the strength and nature of the linear relationship between two variables or characteristics or attribute or quantity. The symbol for the sample correlation coefficient is r. Correlation is measured on a scale of -1 to +1, where 0 indicates no correlation and either -1 or +1 suggest high correlation. Both -1 and +1 are equally high degree of correlation. If one variable can consistently predict the value of the other variable, then a high degree of correlation exist between them [8].

The coefficient of determination, r^2 is the square of the correlation coefficient, r. The coefficient of determination is equal to the percent of variation in one variable that is accounted for (predicted) by the other variable [8].

The standard error about the regression line (often denoted by SE is a measure of the average amount that the regression equation over- or under-predicts. The higher the coefficient of determination, the lower the standard error; and the more accurate predictions are likely to be [8].

In this study the concentration of salinity in the estuaries was measured and computed using the three parameters Electrical Conductivity, Total Dissolved Solids and Chloride. The results were validated using Regression Analysis. The coefficients thus computed are tabulated below to assess the validity among the parameters in various years. The coefficient of determination in all the cases have got more than 0.9 and in most of the cases, it was 0.99. This reveals the strong relationship between the parameters and possibilities to find the concentration of all parameters through the concentration of any of the parameters.

Table: 6 Verification of Validity in Salinity contribution through EC and TDS

Model : Linear Fit : Y=a+bx					
Year	**Coefficients**				
	a	**b**	**s**	**r**	**r^2**
2009	0.637981	0.977307	0.478359	0.986537	0.973255
2010	0.730982	0.979071	0.470615	0.999067	0.998134
2011	0.815878	0.985561	0.541931	0.999012	0.998026
2012	0.451401	0.988710	0.315408	0.999600	0.999201

In this case, EC, the independent variable and TDS is the dependent variable. Considering the year 2009, a straight line can be fitted in an equation Y (TDS) = 0.637981 + 0.977307 X (EC). Here, the slope of the line, 'b' says the X (EC) value contributes only 0.977307 times mg/l and the y intercept, 'a' give information that 0.637981 mg/l residual salinity as TDS available in the station. Correlation coefficient, r is 0.986537 with standard error, S is 0.478359 and the coefficient of determination, r^2 worked out as 0.973255. Similarly the regression constants for the years 2010 2011 and 2012 also worked out and tabulated as above in Table-6.

Table: 7 Verification of Validity in Salinity contribution through TDS and Cl^-

Model : Linear Fit : Y=a+bx					
Year	**Coefficients**				
	a	**b**	**s**	**r**	**r^2**
2009	0.610610	0.970943	0.477779	0.986143	0.972478
2010	-0.300891	1.002495	0.288669	0.999651	0.999302
2011	-1.150892	1.011183	0.407045	0.999456	0.998912
2012	-0.181375	0.995508	0.288561	0.999663	0.999326

For the case of TDS as the independent variable and Cl^- as the dependent variable for the year 2009, the straight line can be fitted in an equation Y (Cl^-) = 0.610610 + 0.970943X (TDS). Here, the slope of the line, 'b' says the X (TDS) value contributes only 0.970943 times mg/l and the y intercept, 'a' give information that 0.610610 mg/l residual salinity as Cl^- available in the station. Correlation coefficient, r is 0.986143 with standard error, S is 0.477779 and the coefficient of determination, r^2 worked out as 0.972478. Similarly the regression constants are worked out and tabulated as above in Table-7 for the years 2010, 2011 and 2012.

Table: 8 Verification of Validity in Salinity contribution through EC and Cl^-

Model : Linear Fit : Y=a+bx					
Year	**Coefficients**				
	a	**b**	**s**	**r**	**r^2**
2009	0.576711	0.972582	0.217775	0.997137	0.994282
2010	0.409369	0.982126	0.396464	0.999342	0.998684
2011	-0.355741	0.997320	0.491051	0.999208	0.998416
2012	0.252287	0.984664	0.287839	0.999664	0.999329

Regarding the case of EC as the independent variable and Cl^- as the dependent variable for the year 2009, the straight line can be fitted in an equation Y (Cl^-) = 0.576711+ 0.972582X (EC). Here, the slope of the line, 'b' says the X (EC) value contributes only 0.972582 times mg/l and the y intercept, 'a, give the information that 0.576711 mg/l residual salinity as Cl^- available in the station. Correlation coefficient, r is 0.997137 with standard error, S is 0.477779 and the coefficient of determination, r^2 worked out as 0.994282. Similarly the regression constants are worked out and tabulated as above in Table-8 for the years 2010 2011 and 2012.

4.5 Application

- The salinity obtained through Electrical Conductivity, Total Dissolved Solids and Chloride is very useful for maintaining the quality of Water Supply Schemes.
- On obtaining any one of the three parameters, concentration of other two parameters can be computed.
- The obtained relationship will help in minimizing the time to assess the status of other two parameters.
- Chances of entry of other pollutants along with the salinity intrusion to the drinking water source can be prevented
- Early actions can be taken for uninterrupted water supply to the scheme area which leads to better water management.
- Utilization of the relationship among the parameters, considerable budget amount can be saved.

V. CONCLUSIONS

- Based on the study carried out it was proved that Salinity obtained through Electrical Conductivity, Total Dissolved Solids and Chloride are very useful for maintaining the quality of Water Supply Schemes.

- The correlation coefficient obtained as 0.999 shows a high relationship between the computed values of salinity and the parameters under consideration.

REFERENCES

Journal:

[1] N.T.Manoj, "Estimation of Flushing Time in a Monsoonal Estuary using Observational and Numerical Approaches", Natural Hazards, National Institute of Oceanography (CSIR), Dona Paula, India, Vol.64,2012:1323-1339

[2] Byung Il Yoon† and Seung-Buhm Woo, "Correlation between freshwater discharge and salinity intrusion in the Han River Estuary, South Korea", Journal of Coastal Research, Special Issue No. 65, 2013 , P 1247-1252

[3] A.Adib, "Determination of Salinity Concentration in Tidal Rivers", Journal of Applied Sciences 8 (14): 2585-2591, 2008, ISSN 1812-5654

[4] LIU Guang-Ming, YANG Jing-Song and YAO Rong- Jiang, "Electrical Conductivity in Soil Extracts: Chemical Factors and Their Intensity", Institute of Soil Science, Chinese Academy of Sciences, Nanjing 21 0008 (China). October 22, 2005, P100-107

[5] M.M.Prabhakaran and G.Resmi, "Periyar River Flow and Kochi Water Supply Scheme- A Comparison of Mass Balance and Measured Values", International Journal of Geology and Environmental Sciences-ISSN-2277-2081

[6] M.M.Prabhakaran and G.Resmi, "Significance of Estuary Discharges in Controlling Salinity - A Case Study on Kochi Water Supply Scheme", International Journal of Advance Research in Science & Engineering - ISSN - 2319-8354

[7] HoaghiaMaria-Alexandra, Cecilia Roman, D. Ristoiu, " Salinity and TDS Variations of Water Wells From Medias City, Sibiu County", Journal of Agriculture- Science and Practice, No. 1- 2(89-90)/2014 , P 73-76

[8] Jeffrey M. Stanton, "Galton, Pearson, and the Peas: A Brief History of Linear Regression for Statistics Instructors", Journal of Statistics Education Volume 9, Number 3 (2001)

Books:

[9] Metcalf & Eddy (1990) "Waste Water Engineering Treatment Disposal Reuse' Tata McGraw-Hill, Second Edition, 1990

[10] Robert H. Stewart, "Introduction to Physical Oceanography: Chapter 6 - Temperature, Salinity and Density – Definition of Salinity", 2005.

[11] Central Public Health and Environmental Organisation, "Manual on Water Supply and Treatment", Third Edition, Ministry of Urban Development, New Delhi, May 1999.

Proceedings:

[12] Zhiming ZHANG, Boashan CUI, Hui ZHAO, Xiaoyun FAN, Honggang ZHANG, "Discharge – Salinity Relationships in Modaomen waterway, Pearl River estuary", International Society for Environmental Information Sciences 2010 Annual Conferences (ISEIS) (P1235-1245), Published by ELSEVIER.

[13] Jose. L.S.Pinho and M.P.Viera, "Mathmematical modeling of salt water intrusion in a Northern Portuguese estuary", Inter-Celtic Colloquium on Hydrology and Management of Water Resources, guimaraes, 07/2005

[14] Joseph M.L, "The Declining Trend of Biodiversity and Fish Production in consequence of Pollution in the lower reaches of Periyar River" - Status Report on Periyar River – 2004, Kerala, India, P43.

[15] P.J.Waite (1980) "Control of salt water intrusion in estuaries by means of a dual purpose reservoir" Proceedings of the Oxford Symposium, April 1980