Analysis of Water Quality Parameters of Valliyaru River, Kanyakumari District, Tamilnadu, India

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Abstract - Valliyaru river is one of the major water source of kanyakumari district, India, aiding the local population for domestic and agricultural activities. Vellimalai hills, the southernmost tip of Western Ghats of India serves as the feeding area for this river. It flows through the thickly populated residential area and vast agricultural fields and engulfed by Arabian Sea. The physical, chemical and microbial parameters are measured at five different locations from September to December, NE Monsoon period of 2013. The physico-chemical parameters of Valliyaru River are compared with WHO standards. Statistical regression analyses for 22 different water quality parameters were performed and the correlation coefficients were calculated.

Key Words: Valliyaru River, Water Quality Parameter, Regression equation, Correlation Analysis, Vellimalai hills.

I. INTRODUCTION

Water, an elixir of life is an important natural resource for human existence. Three fourth of our earth is surrounded by water, but a meager portion of it is used for human activities such as domestic, industrial and agricultural uses. Even though, water is an abundant renewable resource; reckless usage and improper management of it causes depletion. Contamination of water, particularly by human actions can occur chemically and biologically and become unfit for domestic, agricultural and industrial uses [1, 2]. Agricultural runoff and domestic-sewage pollutes water bodies, which results in eutrophication. The other important sources of water pollution include mass bathing, disposal of dead bodies, rural and urban waste matters and solid waste disposal. Ramification of climate change also causes water pollution. Indian rivers have been deteriorating in the last three decades due to incessant discharge of agricultural run-off, industrial and domestic wastes [3]. Study of physico-chemical parameters of some rivers have been made by a number of workers [4, 5].

Investigations of the quality of water are continuously performed by various governments and researchers around the world which helps to control water pollution [6, 7]. Statistical analysis provides information and behavior of water resources.

Valliyaru river which flows in Kanyakumari District (Fig 1a) origins from Vellimalai hills near Muttaikadu. Vellimalai hills has an altitude of around 1600feet from the mean sea level.

Valliyaru irrigation area has vast agricultural land which is used mainly for rubber plantation followed by banana, coconut and other crops. No major industries are present except for some small rubber and cashew processing industries.

From Muttaikadu, it flows through Padmanabapuram and Thuckalay. Kalkurichi, which is a part of Thukalay municipality has a population of nearly 22,000, use this river mainly for domestic purpose, agriculture and a few rubber industries.

A tributary river called as Thoovalaru joins here and flows downhill to Eraniel which has a population of around 10,000. Agricultural runoff and sewage are being discharged into this river. Throughout the downhill flow it feeds so many ponds, which are essential for agriculture.

From Eraniel, it flow further downhill to Cheramangalam, where it feeds Periyakulam pond which has an area of 152 acres, most of the water area covered with algae.
This pond supplies water to several hectares of paddy fields from which agricultural runoff is discharged into the water.
From Cheramangalm, water flows through Manavalakurichi and ultimately reaches Kadiyappattanam, where it merges with Arabian Sea. Kadiyapattinam is fishing hamlet, which is spread along the sea shore.
Valliyaru, form the origin to the end, flows downhill for approximately 22km. Water samples were collected from September to December of 2013. Various water quality parameters were evaluated with standard methods and statistical analysis were made.

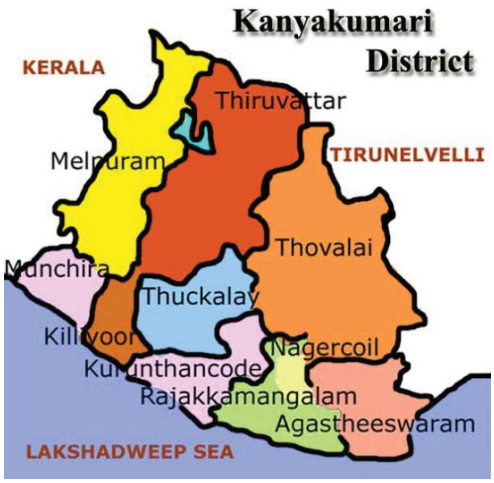

Fig 1 a

Fig 1 b

Fig 1 a - Map of kanyakumari District, Tamilnadu, India

Fig 1 b – Flow of Valliyaru River across Kanyakumari District and water collected from five different locations.

II. MATERIALS AND METHODS

Water samples were collected in clean plastic bottles from five different locations namely Muttaikadu, Kalkurichy, Eraniel, Cheramangalam and Kadiyappattanam region of Valliyaru river as shown in Fig. 1 b. 22 water quality parameters such as Turbidity, Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, Alkalinity, Total Hardness (TH), Calcium (C_a^{2+}), Magnesium (M_g^{2+}), Sodium (Na^+), Potassium (K^+), Iron ($Fe^{2+/3+}$), Manganese (Mn^{2+}), Ammonia (NH_3), Nitrite (NO_2), Nitrate (NO_3^-), Chloride (Cl^-), Fluoride (F^-), Sulphate (SO_4^{2-}), Phosphate (PO_4^{3-}), Dissolved oxygen (DO), Biological Oxygen Demand (BOD) and Coliform (Coli) were estimated by standard techniques [8-10].

The important statistical parameters of physico-chemical characteristics of analyzed water samples viz., Mean, Standard Deviation (SD), Standard Error (SE) and Coefficient of Variation (CV) were calculated. The correlation analysis between various water quality parameters was studied by regression analysis using Microsoft Excel version 2010. Correlation analysis measures the nearness of the relationship between chosen independent and dependent variables. If the correlation coefficient is nearer to +1 or –1, it gives a linear relationship between two variables. The correlation between the two parameters is characterized as very strong, when it is in the range of +0.8 to 1.0 and -0.8 to -1.0, fair: when having values in the range of +0.5 to 0.8 and -0.5 to -0.8, very poor: when it is in the range of +0.0 to 0.5 and-0.0 to -0.5 [11]. Correlation analysis helps to establish the relationship between the variables [12].

III. RESULTS AND DISCUSSIONS

Water quality parameters obtained by standard methods of Valliyaru river during the period from September to December 2013 (Mean values for four months) and WHO standards are given in Table 1. Various water quality parameters are well within the WHO standard values except for EC, Ca2+, Mg2+, Na+ and K+. Exceeding values of these parameters from WHO standards are observed maximum at Kadiyappatanam followed by Cheramangalam. But water from other collection sites has values within the WHO Standards. Kadiyappatanam is the place where Valliyaru and Arabian sea joins together and it is obvious that the values for the above mentioned parameters are high than the WHO Standards.

Table 1. Physicochemical & biological parameters of Valliyaru river during NE Monsoon for 2013

Parameters	WHO standards	2013 - NE Monsoon				
		Muttai kadu	Kal curicy	Eraniel	Chera mangalm	Kadiyap patanam
Turbidity	-	12	10	13	11	14
TDS	500 – 1500 mg/l	115	301	336	410	487
EC	300 mg/l	191	343	216	437	460
pH	6.9 – 9.2	7.86	8.01	8.3	8.34	8.37
Alkalinity	-	20	34	44	76	101
TH	100 – 500 mg/l	45	89	265	321	431
C_a^{2+}	75 – 200 mg/l	21	26	167	387	578
M_g^{2+}	30 – 150 mg/l	23	46	125	543	612
Na^+	50 – 60 mg/l	12	34	99	123	321
K^+	20 mg/l	4	65	112	265	321
$F_e^{2+/3+}$	-	2.01	2.23	2.16	2.09	1.89
Mn^{2+}	-	0.33	0.33	0.33	0.33	0.33
NH_3	-	0.3	0.98	0.46	0.38	0.31
NO_2	-	0.11	0.12	0.3	0.34	0.4
NO_3^-	40 – 50 mg/l	1	2	1	2	2
Cl^-	200 – 600 mg/l	20	45	67	98	145
F^-	1 – 1.5 mg/l	0.2	0.4	0.4	0.4	0.2
SO_4^{2+}	200 – 250 mg/l	1	3	6	8	13
PO_4^{3+}	-	0.4	0.89	0.55	0.98	1.34
DO	-	6.4	7	7.3	6.7	6.7
BOD	-	9	12	12	6	9
Coli	-	2370	2260	2310	2280	1420

The maximum value, minimum value, range, mean, standard deviation, standard error & percentage coefficient of variation for various quality parameters of water collected during the NE Monsoon period of 2013 is given below in Table 2. The coefficient of variations for EC, Alkalinity, TH, C_a^{2+}, M_g^{2+}, Na^+, K^+ and Cl^- are found to be 37.44, 59.92, 70.05, 102.76, 105.44, 103.87, 87.70 and 64.70 % respectively. So, it is clear that variation of values for these parameters is high in different locations; generally maximum at the origin and the increases along its downhill way and maximum at Kadiyappattanam.

Table 2: Statistical analysis of Valliyaru River water Sample – NE Monsoon (2013)

Parameters	Max	Min	Range	Mean	SD	SE	CV%
Turbidity	14.00	10.00	4.00	12.00	1.58	0.71	13.18
TDS	487.00	115.00	372.00	329.80	139.78	62.51	42.38
EC	460.00	191.00	269.00	329.40	123.32	55.15	37.44
pH	8.37	7.86	0.51	8.18	0.23	0.10	2.78
Alkalinity	101.00	20.00	81.00	55.00	32.95	14.74	59.92
TH	431.00	45.00	386.00	230.20	161.26	72.12	70.05
C_a^{2+}	578.00	21.00	557.00	235.80	242.31	108.36	102.76
M_g^{2+}	612.00	23.00	589.00	269.80	284.47	127.22	105.44
Na^{+}	321.00	12.00	309.00	117.80	122.36	54.72	103.87
K^{+}	321.00	4.00	317.00	153.40	134.53	60.16	87.70
$F_e^{2+/3+}$	2.23	1.89	0.34	2.08	0.13	0.06	6.37
Mn^{2+}	0.33	0.33	0.00	0.33	0.00	0.00	0.00
NH_3	0.98	0.30	0.68	0.49	0.28	0.13	58.34
NO_2	0.40	0.11	0.29	0.25	0.13	0.06	51.90
NO_3^{-}	2.00	1.00	1.00	1.60	0.55	0.24	34.23
Cl^{-}	145.00	20.00	125.00	75.00	48.52	21.70	64.70
F^{-}	0.40	0.20	0.20	0.32	0.11	0.05	34.23
SO_4^{2+}	13.00	1.00	12.00	6.20	4.66	2.08	75.13
PO_4^{3+}	1.34	0.40	0.94	0.83	0.37	0.17	44.55
DO	7.30	6.40	0.90	6.82	0.34	0.15	5.02
BOD	12.00	6.00	6.00	9.60	2.51	1.12	26.15
Coli	2370.00	1420.00	950.00	2128.00	397.96	177.97	18.70

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Table 3: Correlation coefficients among various water quality parameters – NE Monsoon (2013)

Parameters	Turbidity	TDS	EC	pH	Alkalinity	TH	C_a^{2+}	M_g^{2+}	Na^+	K^+	$Fe^{2+/3+}$	NH_3	NO_2	NO_3^-	Cl^-	F^-	SO_4^{2+}	PO_4^{3+}	DO	BOD	Coli
Turbidity	1.00																				
TDS	0.34	1.00																			
EC	0.02	0.84	1.00																		
pH	0.47	0.92	0.63	1.00																	
Alkalinity	0.49	0.92	0.87	0.85	1.00																
TH	0.62	0.92	0.70	0.95	0.95	1.00															
C_a^{2+}	0.58	0.87	0.80	0.84	0.99	0.96	1.00														
M_g^{2+}	0.40	0.84	0.87	0.80	0.97	0.90	0.97	1.00													
Na^+	0.71	0.84	0.71	0.77	0.94	0.91	0.94	0.85	1.00												
K^+	0.42	0.93	0.87	0.88	0.99	0.95	0.98	0.98	0.89	1.00											
$Fe^{2+/3+}$	-0.73	-0.24	-0.32	-0.23	-0.58	-0.50	-0.67	-0.60	-0.70	-0.52	1.00										
NH_3	-0.70	-0.07	0.01	-0.30	-0.37	-0.44	-0.50	-0.47	-0.41	-0.37	0.78	1.00									
NO_2	0.62	0.88	0.63	0.97	0.91	0.99	0.93	0.88	0.86	0.92	-0.48	-0.50	1.00								
NO_3^-	-0.29	0.68	0.93	0.38	0.64	0.43	0.53	0.63	0.46	0.65	-0.06	0.34	0.34	1.00							
Cl^-	0.55	0.94	0.82	0.88	0.99	0.97	0.98	0.94	0.96	0.98	-0.56	-0.35	0.93	0.59	1.00						
F^-	-0.58	0.19	0.03	0.24	-0.15	-0.04	-0.24	-0.15	-0.36	-0.06	0.87	0.58	-0.01	0.17	-0.14	1.00					
SO_4^{2+}	0.61	0.93	0.77	0.89	0.98	0.98	0.97	0.91	0.97	0.96	-0.57	-0.38	0.94	0.53	1.00	-0.16	1.00				
PO_4^{3+}	0.20	0.87	0.96	0.64	0.89	0.74	0.82	0.83	0.83	0.87	-0.40	0.03	0.66	0.88	0.88	-0.09	0.85	1.00			
DO	0.00	0.31	-0.13	0.38	-0.05	0.15	-0.12	-0.21	-0.03	-0.04	0.64	0.49	0.17	-0.08	0.04	0.72	0.08	-0.04	1.00		
BOD	0.00	-0.22	-0.50	-0.27	-0.48	-0.37	-0.53	-0.67	-0.26	-0.54	0.51	0.60	-0.39	-0.33	-0.38	0.22	-0.33	-0.30	0.68	1.00	
Coli	-0.66	-0.69	-0.65	-0.52	-0.81	-0.72	-0.81	-0.70	-0.94	-0.73	0.73	0.27	-0.64	-0.49	-0.84	0.53	-0.84	-0.82	0.14	0.12	1.00

The numerical values of correlation coefficient, R for the 22 parameters are given in Table 3. It clearly highlights the interrelationship of various water quality parameters. Correlation values are observed for Turbidity between EC-TH, C_a^{2+}, M_g^{2+}, Na^+, K^+, Cl^-, SO_4^{2-} and BOD. High negative correlation values exist between $F_e^{2+/3+}$ and DO for Turbidity.

Positive correlation is observed between TH – C_a^{2+}, M_g^{2+} & EC. Hardness causes heart diseases in human.

Hardness above 200ppm cause scales in water pipes and distribution system. However, it is observed that, water collected from Kadiyappattanam only has Hardness values above 350ppm. Strong correlation exists between pH - Alkalinity, Total Hardness (TH), Sodium (Na^+), Dissolved oxygen (DO) and Sulphate (SO_4^{2-}) ion. Alkalinity has significant correlation with negative ions such as nitrite and fluoride ion. Iron has strong correlation with the entire negative ions present in the water.

Table 4: Linear correlation coefficient R and regression equation of Valliyaru River water Sample - NE Monsoon (2013)

Pairs of Parameters	R Value	Regression Equation
Alkal - C_a^{2+}	0.989	C_a^{2+} = 7.2737 Alkal - 164.25
Alkal - M_g^{2+}	0.97	M_g^{2+}= 8.3814 Alkal - 191.18
Alkal – K^+	0.992	K^+ = 4.0502 Alkal - 69.36
Alkal – Cl^-	0.992	Cl^- = 1.4609 Alkal - 5.3476
Alkal - SO_4^{2-}	0.98	SO_4^{2-}= 0.1386 Alkal - 1.422
TH – NO_2	0.991	NO_2= 0.0008 TH + 0.0674
C_a^{2+} - M_g^{2+}	0.973	M_g^{2+}= 1.1426 C_a^{2+} + 0.3787
C_a^{2+} – K^+	0.979	K^+ = 0.5438 C_a^{2+}+ 25.171
C_a^{2+} – Cl^-	0.98	Cl^- = 0.1963 C_a^{2+}+ 28.724
C_a^{2+} - SO_4^{2-}	0.974	SO_4^{2-}= 0.0187 C_a^{2+}+ 1.781
M_g^{2+}– K^+	0.983	K^+ = 0.4649 M_g^{2+}+ 27.968
Na^+- SO_4^{2-}	0.97	SO_4^{2-}= 0.037 Na^+ + 1.8465
K^+ – Cl^-	0.976	Cl^- = 0.3522 K^+ + 20.968
Cl^- - SO_4^{2-}	0.996	SO_4^{2-}= 0.0957 Cl^- - 0.9751

The linear regression analyses have been carried out for five water quality parameters which are found to have correlation coefficient values above 0.97 and the regression equations obtained are given in the Table 4. It is obvious from the study that very strong correlation exist between Alkal - C_a^{2+} (Fig 2), Alkal - M_g^{2+} (Fig 3), Alkal – K^+ (Fig 4), Alkal – Cl^- (Fig 5), Alkal - SO_4^{2-} (Fig 6), TH – NO_2 (Fig 7), C_a^{2+} - M_g^{2+} (Fig 8), C_a^{2+} – K^+ (Fig 9), C_a^{2+} – Cl^- (Fig 10), C_a^{2+} - SO_4^{2-} (Fig 11), M_g^{2+}– K^+ (Fig 12), Na^+- SO_4^{2-} (Fig 13), K^+ – Cl^- (Fig 14) and Cl^- - SO_4^{2-} (Fig 15). Therefore it is obvious from the results that ions such as mentioned above play a significant role in increased Electrical Conductivity and Total dissolved solids. TDS is correlated with TH (0.92) which is clear that C_a^{2+} and M_g^{2+} ions influence these two parameters. No significant correlations exist between many water quality parameters viz., Turbidity – TDS (0.337), Alkalinity – NH_3 (-0.371), C_a^{2+} - DO (-0.119), TH – NH_3 (-0.443) and Turbidity - EC (0.016).

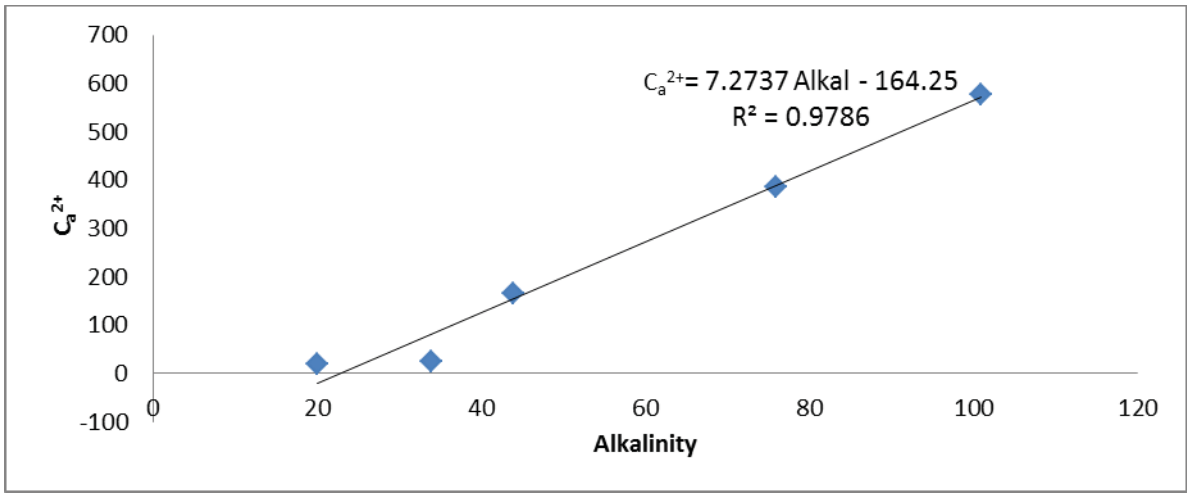

Fig 2: Correlation between Alkal and C_a^{2+}

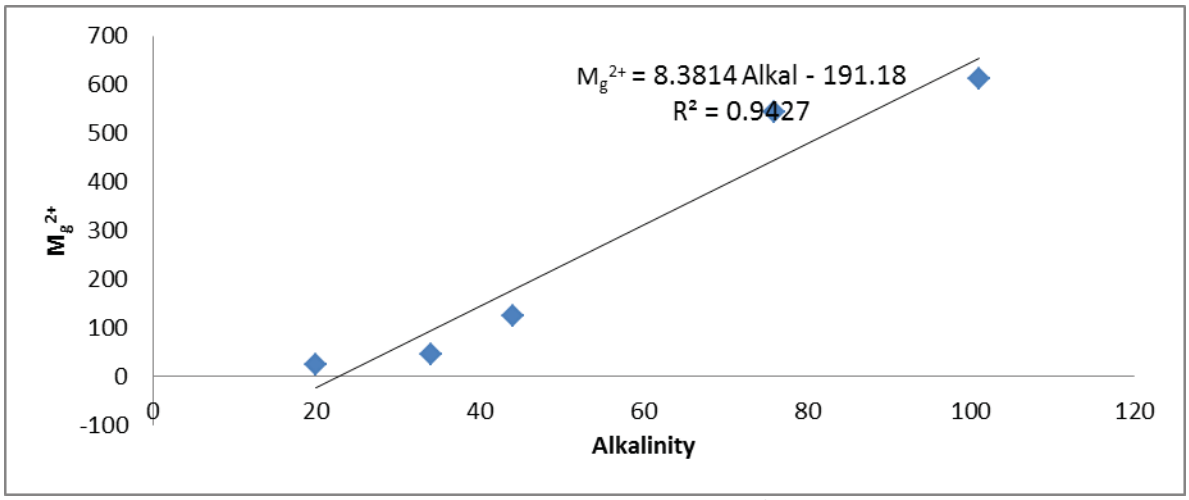

Fig 3: Correlation between Alkal and M_g^{2+}

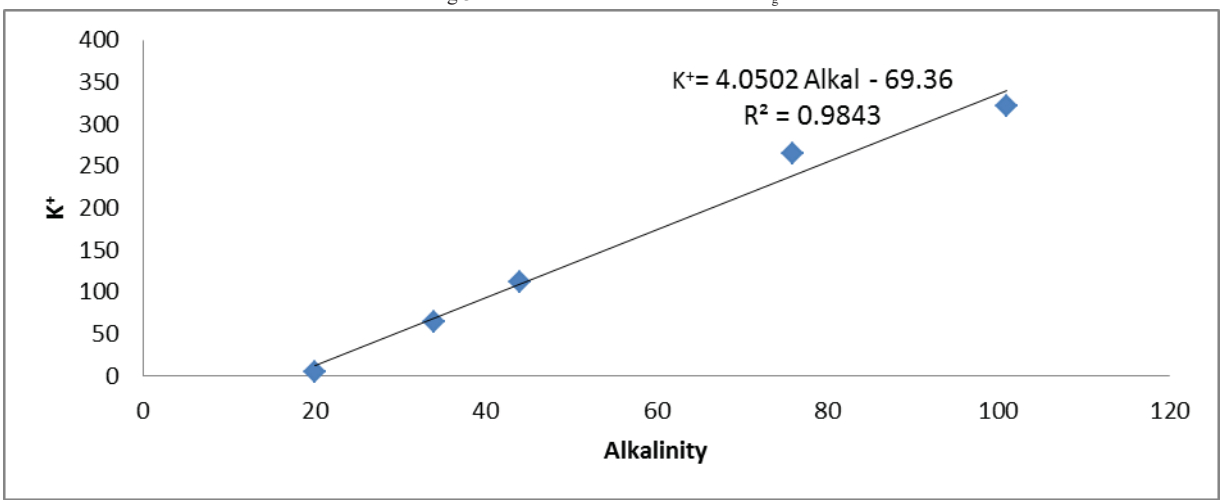

Fig 4: Correlation between Alkal and K^+

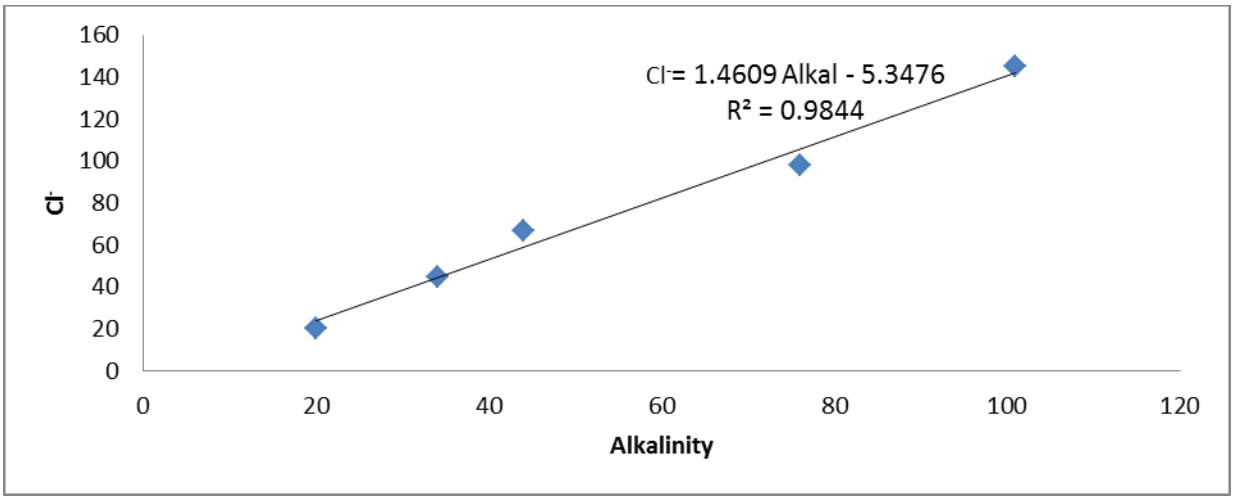

Fig 5: Correlation between Alkal and Cl^-

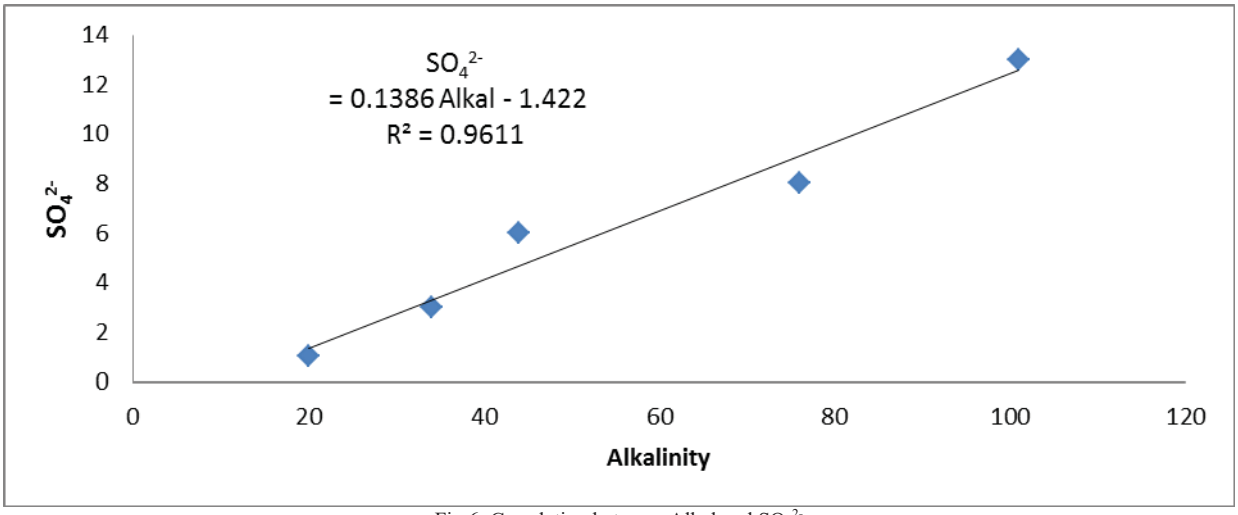

Fig 6: Correlation between Alkal and SO_4^{2-}

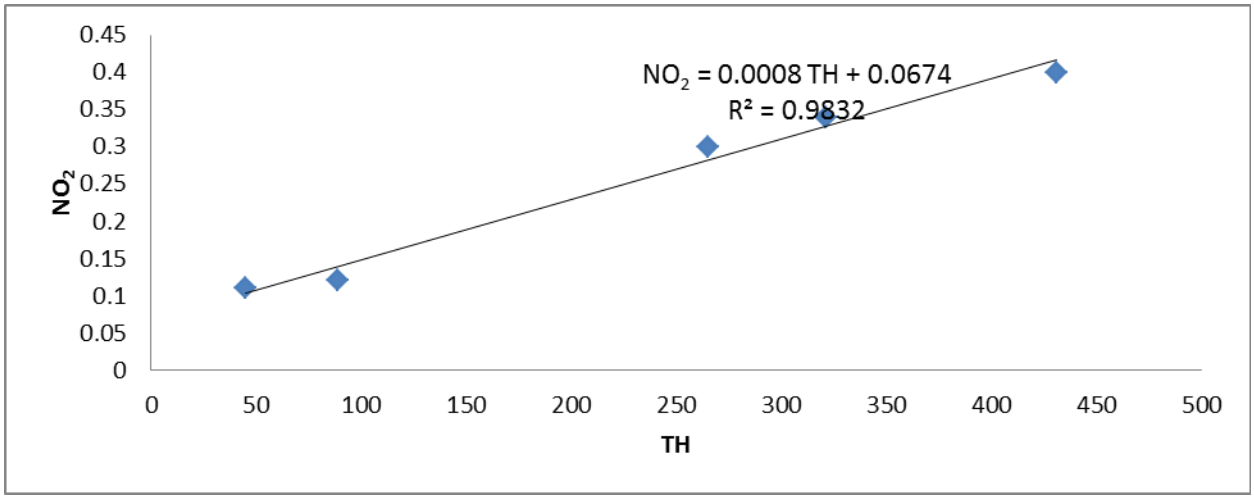

Fig 7: Correlation between TH and NO_2

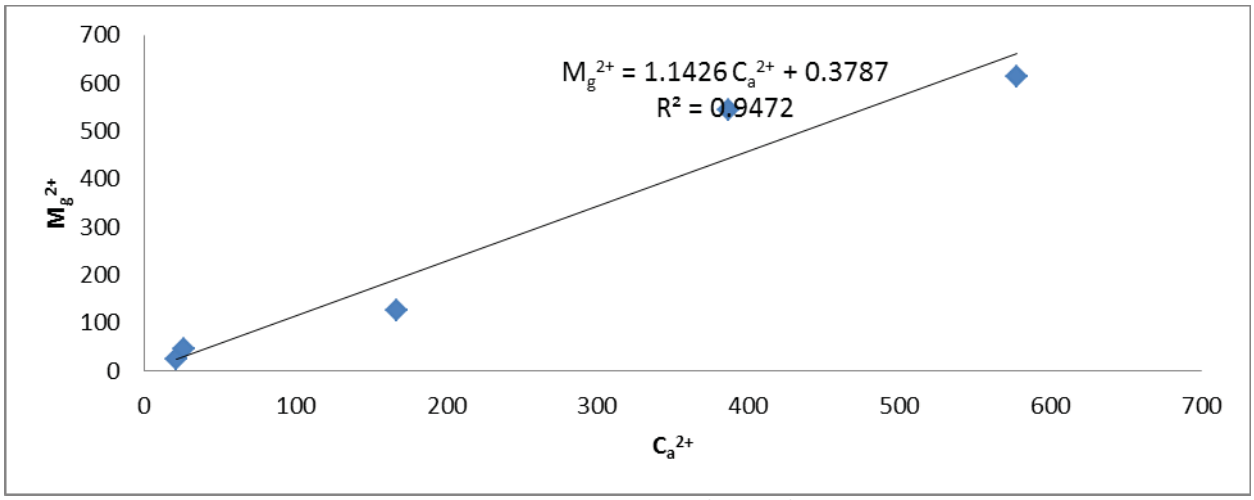

Fig 8: Correlation between C_a^{2+} and M_g^{2+}

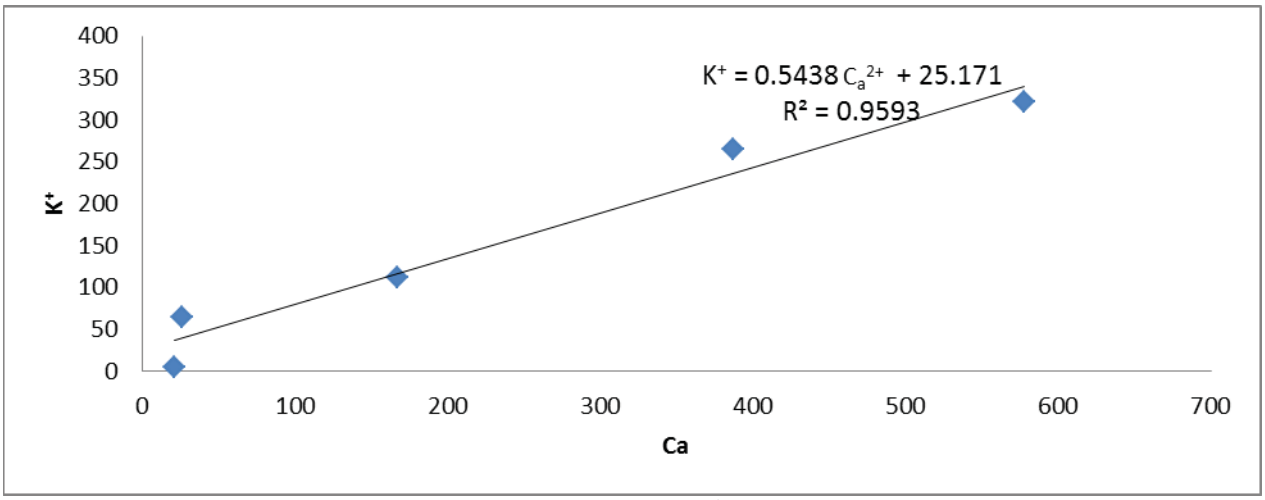

Fig 9: Correlation between C_a^{2+} and K^+

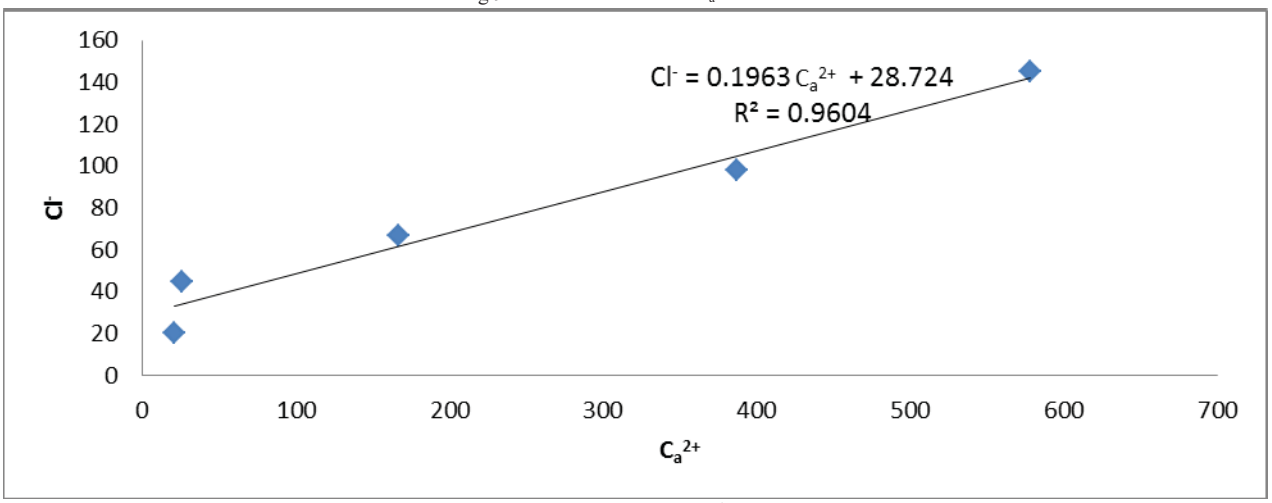

Fig 10: Correlation between C_a^{2+} and Cl^-

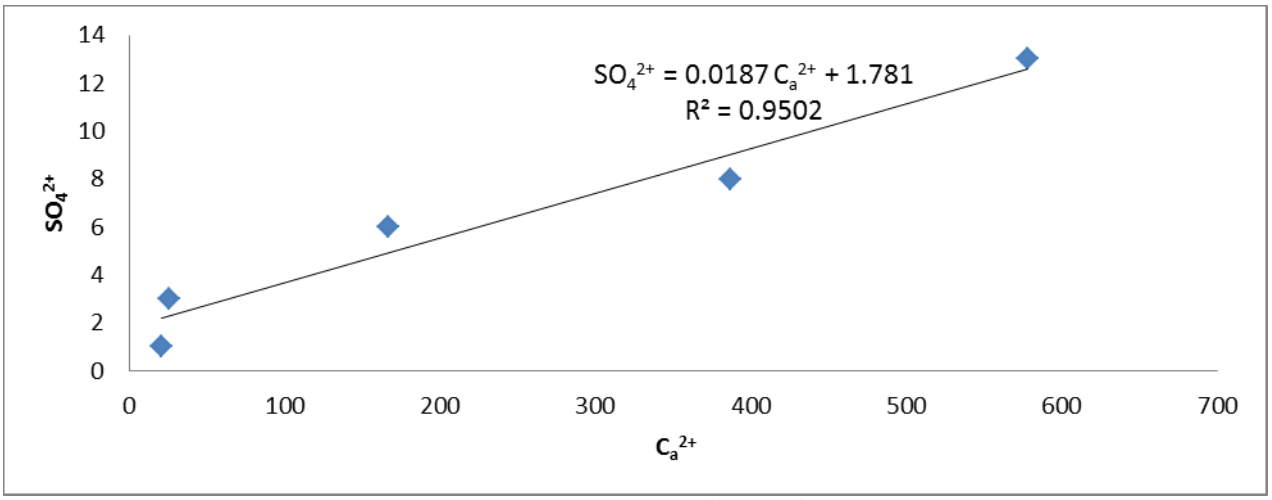

Fig 11: Correlation between C_a^{2+} and SO_4^{2-}

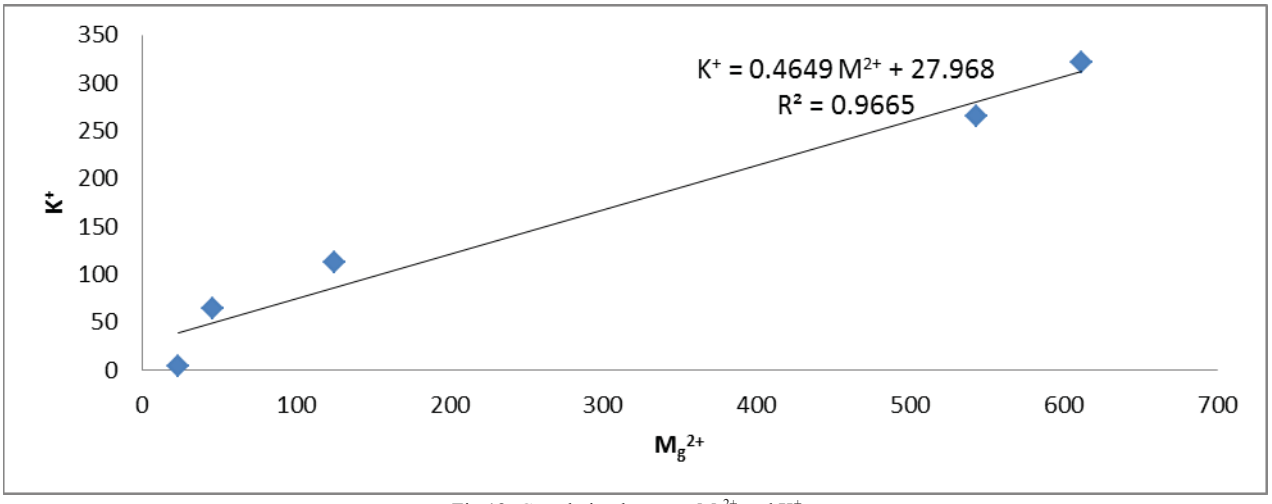

Fig 12: Correlation between M_g^{2+} and K^+

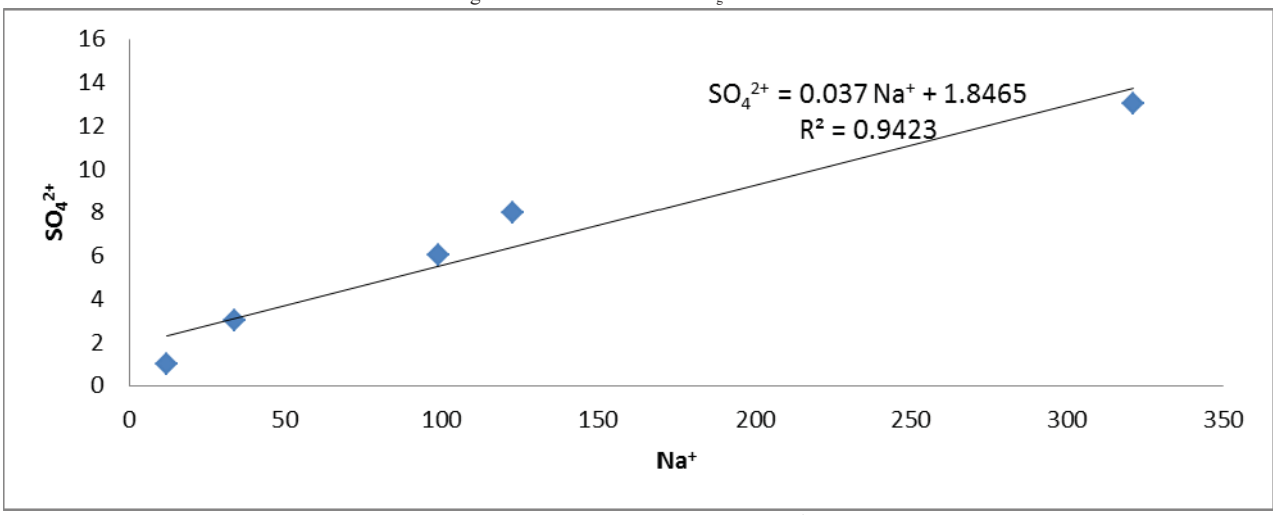

Fig 13: Correlation between Na^+ and SO_4^{2}

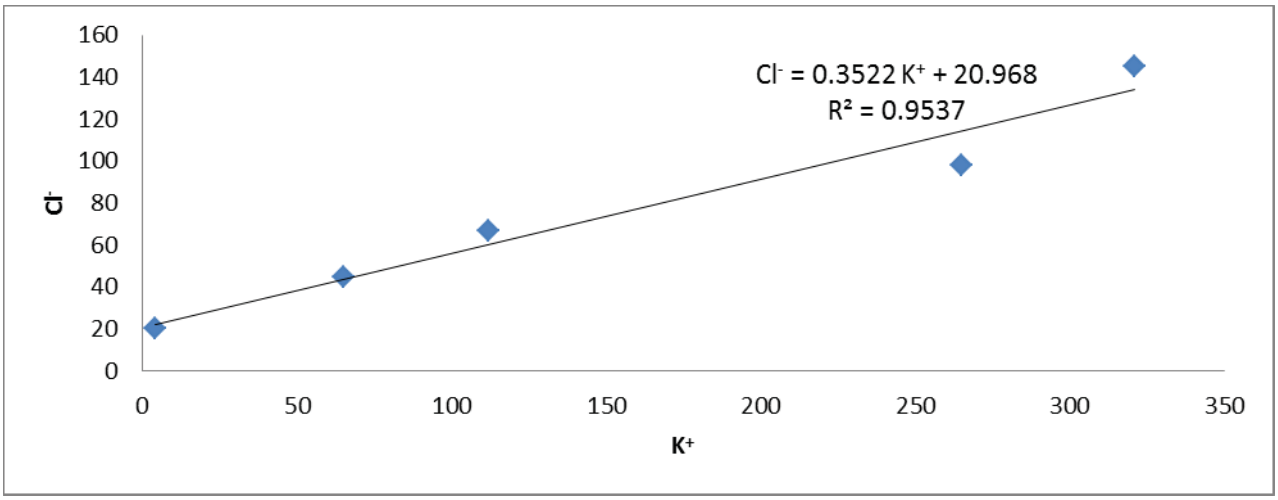

Fig 14: Correlation between K^+ and Cl^-

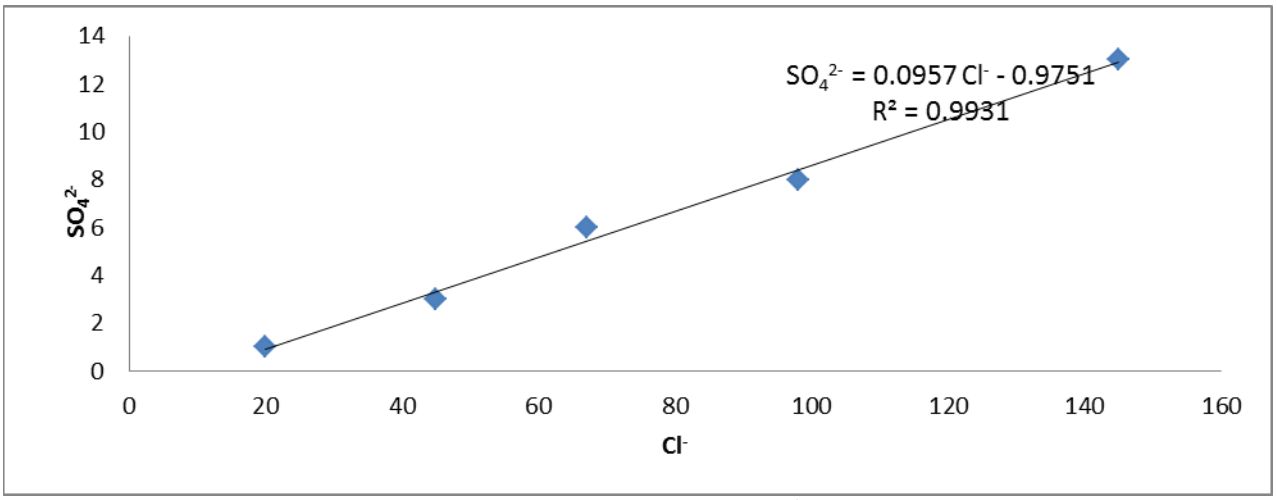

Fig 15: Correlation between Cl^- and SO_4^{2-}

IV. CONCLUSION

Water quality assessment of Valliyaru river reveals that many water quality parameters are within the WHO standards. However certain parameters such as TDS, C_a^{2+}, M_g^{2+}, Na^+ and K^+ are relatively high for Kadiyappattanam and to a certain extent at Cheramangalam than other collection sites, which is attributed to the sea water intrusion. Despite, thick population and vast agricultural fields, the river water is not highly polluted with organic and inorganic wastes from domestic sewages and agricultural run-off. Water at the origin, Muttaikadu and Eraniel are not polluted but a small variation only is observed between them, which are not significant. In general, the study reveals that the Valliyaru river water is not significantly polluted during the NE Monsoon period.

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