International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue 10, October 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

ASSESSMENT OF SALINITY INTRUSION THROUGH PERIYAR RIVER ESTUARIES

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ABSTRACT

Albeit distinctive models are at present standard devices for expectation of salinity intrusion in estuaries, different estuary researchers tend to utilize reliable and dependable devices, for instance, experimental models. These models can be utilized as a rapid mechanism to censer the salt intrusion length as a component of distinctively quantifiable constraints. The aim of this study was to compare the empirical models performance and that of real measured values. To accomplish this, use of an empirical model and a few of years actual measured values are assessed for expectation of saltiness intrusion in the Periyar River estuary. Field data were utilized for calibration and verification of the values acquired through empirical model. Using the confirmed model values through the model, meticulous circumstances were considered during the time to hub the perfect riverine stream under different conditions. Eventually, the salinity intrusion in Periyar River was studied by empirical models to locate the suitable model for forecast of the salinity intrusion length. The Salinity Intrusion length was worked out utilizing Brockway Model (2006) and found that the interruption length was inversely proportional to the estuarine river discharge.

Keywords: Empirical Model, Estuaries, Intrusion Length, Periyar River, Salinity Intrusion

I. INTRODUCTION

The salinity intrusion processes of estuaries are overwhelmingly administered by the measure of fresh water release and the estuarine salinity concentration. In the meantime the profundity overseeing geometrical elements and the velocity of fresh water release likewise assumes dynamic parts in the salinity intrusion processes [2]. Because of this, it is chosen to ponder the salinity intrusion length in the salinity intrusion processes.

Estuaries, where fresh water from rivers mixes with salt water from the seas, are among the most beneficial situations on earth. The estuary is not a part of the coast but rather is a coastal feature with a persistent exchange of water between land and the sea [8]. The intrusion of sea water in estuaries is a mesmerizing spectacle which happens naturally and influences the nature of the water for varied purposes. Notwithstanding morphological characteristics of an estuary, salinity intrusion depends emphatically on the salinity disparity among sea and river water and the amount of riverine flow [5]. Combinations of the above elements decide the mixing mechanism in an estuary and the salinity intrusion length. Salinity intrusion may diminish the estuarine water quality to that its water gets to be unacceptable for some uses such as drinking and agricultural purposes [7]. In this manner determination of the salinity distribution along an estuary is a principle enthusiasm for water engineers in coastal regions. Since the physical modelling of seawater intrusion is an estuary is tedious and costly, it is chosen to utilize equipments like empirical models. This paper deals such an endeavour of Periyar estuaries in Kerala. The Periyar estuaries have free connections with the Arabian Sea is the most essential water resource for Kochi City, the business capital of Kerala. Along the estuary some intake stations have been made to supply different water needs and it is imperative to keep the water salinity below a sure certain level at these intake stations. Here for Kochi City, the intake point situates at Aluva [3].

The initial studies for this work have been carried out utilizing both Numerical Analysis and Harleman Empirical Model [6]. The aims of this paper are: (1) the determination of riverine flow discharge for different salinity concentrations, to keep the salinity under a certain level at intake station that is located about 20 km from the estuaries, and (2) Evaluation of Brockway Model to assess the suitability of Periyar River Estuaries to predict the Salinity intrusion length [1].

To accomplish these points, an one dimensional model organized by J.Parsha et.al; (2007) in view of a set up model of the well known scientist Savanaji(1993) to compute the salinity intrusion length was utilized. After calibration of the model using field data, it was confirmed utilizing another set of field data. The verified model was then utilized for computing of salinity intrusion in this estuary at diverse conditions.

II. STUDY AREA

Periyar River estuaries, situated in the central-west of Kerala are one of the primary inland waterways in Kerala. The back water of this portion is known as Venbanad Kayal. It has a length of 96.5km and 14km width with an average area of 2033 Sq.km. The first upstream dam of the estuary is Bhoothathankettu. The averaged cross sectional area, width and depth of Periyar estuary are around 3980 m2, 920 m and 4.2 m respectively. The annual average discharge through the estuaries is noted as 206 m3/sec. Amid dry season, usually in summer, when the Periyar discharge is low, the salinity intrusion influences the drinking water production, despite the fact that the intake is more than 20 km upstream of the estuary. However under diverse riverine flow, profundity of water and salinity concentrations, water surface elevation and water quality of Periyar River along its entire course are unequivocally influenced. As the salinity in Periyar River estuaries is high in its beginning bits, it is not suitable for agricultural use furthermore influencing the intake of drinking water source at 20 km upstream. The salinity of the Periyar estuaries varies between 2000 and 4500 mg/l, with maximum salinity of 4500mg/l [4].

A detailed monthly mass balance study has been carried out and the flow for the selected stations for ten years was worked out. The obtained flow was compared with the actual flow recorded in the selected stations [3].

In Salinity intrusion studies, the minimum discharge required through the estuaries is found out so as to maintain the quality of source for an uninterrupted Water Supply to Kochi. In this regard, a work on flow optimization has been carried out by keeping the water quality standards insisted by the CPHEEO. The work has been carried out using Harleman's Empirical Model [6]. It reveals the minimum discharge required for controlling salinity intrusion and also a better resource management.

International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue 10, October 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

III. METHOD OF STUDY

A lot of studies related to Salinity intrusion through Estuaries has been carried out all over the world. But as per literature most of such studies are of laboratory type. Mr.Savaniji, a renowned researcher in this field from DELFT, Netherlands have carried out practical studies and established Models. In 2005, Mr.Savaniji has examined around 43 rivers all over the world and established an empirical relationship. His works about salinity intrusion through the estuaries are of three dimensional mixing. But based on these studies, another researcher named Mr. Brockway from Washington University in 2006, has built up an empirical Model which is simpler and giving axial mixing which is more suitable for the analysis of drinking water sources [1]. Considering these facts this work has been carried out utilizing Brockway Model and found that it is suitable for Periyar estuaries too.

The Brockway Model is given to find out the Salt Water Intrusion Length,

That is; the intrusion length, $X_L = [1/\beta] \ln [(4.6 A_0 \beta K_x/Q) +1]$ – (1) for 2 ppm

Here, A_0 is the cross-sectional area of the entrance of estuary and β is the reduction factor or the extent of topographical convergence of the estuary.

In our study, the A_0 is (the sum of two estuaries A1 and A2)

At Purappellikkav side, A1

Width (Average) – 600 mts, Depth (Average) – 4.50 mts, and Average area of Cross Section = 2700 m^2

At Eloor side, A2

Width (Average) – 320 mts, Depth (Average) – 4.00 mts, and Average area of Cross Section = 1280 m^2

Total Area of Cross-section A_0 = 3980 m^2

At Aluva side, A3

Width (Average) – 280 mts, Depth (Average) – 2.50 mts, and Average area of Cross Section = 700 m^2

Topographical Convergence, β = 0.17588,

Slope of the River stretch is 7.14 mts per one Kilometre, i.e;= 0.00714

As the salinity intrusion is high during low fresh water discharge, so for this calculation the fresh water discharge is considered as, Q = 2 m3/sec

Mixing Coefficient for the axial Direction,

$K_x = (-Q/ (\beta A_0 Slope))$, i.e, K_x =0.40016

Applying the above values in the Brockway Model, Salt Water Intrusion Length,

$X_L = [1/\beta] \ln [(4.6 A0 \beta Kx/Q) +1]$

A salinity concentration of 2 units will be at the intrusion length of 36.7846 km

Converging Section Width in mts = 280 Mts , Slope of River Stretch = 0.00714

Accordingly, the intrusion length for three years has been worked out using Brockway Model and tabled below. The particulars of Table 2, Table 3 and Table 4 are mentioned as A to J. The details of A to J described below vide Table 1.

Table 1Description of Table2

Column	Description	Column	Description
A	Month	F	Converging Section Depth in mts
B	Fresh Water Discharge, Q	G	Converging Area B_0 in m^2
C	Average Width at Estuary in mts	H	Topographical Convergence, β
D	Average Depth at Estuary in mts	I	Mixing Coefficient, K_x
E	Cross section Area, A_0 in m^2	J	Salt Water Intrusion Length, X_L, in Km

Table 2 Computation of Salinity Intrusion Length During 2008

A	B	C	D	E	F	G	H	I	J
Jan	13.24	916	4.30	3938.80	1.80	504.00	0.128	3.68	50.56
Feb	6.76	915	4.20	3843.00	1.70	476.00	0.1239	1.99	52.23
Mar	13.42	920	4.30	3956.00	1.90	532.00	0.1345	3.53	48.11
Apr	31.91	922	4.40	4056.80	2.00	560.00	0.138	7.98	46.87
May	68.84	922	4.50	4149.00	2.20	616.00	0.1485	15.65	43.58
Jun	212.96	928	6.20	5753.60	5.50	1540.00	0.2677	19.37	24.17
Jul	475.88	930	6.40	5952.00	6.10	1708.00	0.287	39.02	22.55
Aug	489.34	930	5.50	5115.00	5.60	1568.00	0.3065	43.71	21.10
Sep	1069.91	930	5.90	5487.00	5.70	1596.00	0.2909	93.89	22.24
Oct	303.12	929	5.10	4737.90	4.20	1176.00	0.2482	36.10	26.07
Nov	256.17	929	5.30	4923.70	3.90	1092.00	0.2218	32.86	29.17
Dec	15.61	920	4.90	4508.00	2.40	672.00	0.1491	3.25	43.40

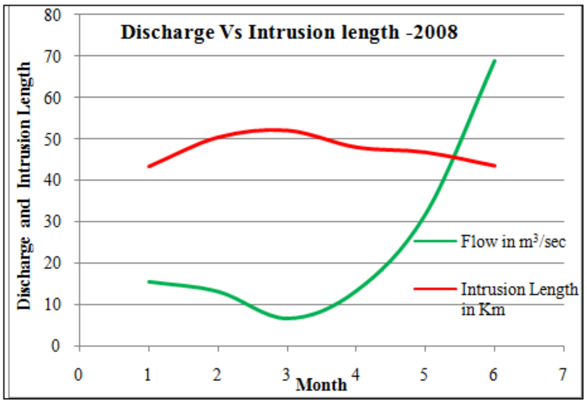

Fig 1 Month Wise Discharge and Salinity Intrusion Length for Year 2008

The salinity intrusion length varies between 21.10 and 52.23 during the month of August and February in 2008. Referring to Table 2, the discharge during the month of August was good. But the highest discharge was during September month and salinity was a little higher than that in August. This may be due to some other factors, like tidal variations etc, which are not considered for this study. It is observed that the study is not effective for monsoon season, as we do not give much attention to the monsoon problems through salinity intrusion. In short, the salinity intrusion length is about inversely proportional to the fresh water discharges through the estuaries is depicted in Fig 1.

Regarding the year 2009, the salinity intrusion length varies between 22.53 for the month of July and September, and 53.76 during the month of February. Even though the discharge during the months of July and September were not equal the salinity documented was same as per Table 3.

Table 3 Computation of Salinity Intrusion Length During 2009

A	B	C	D	E	F	G	H	I	J
Jan	3.48	914	4.10	3747.40	1.70	476.00	0.127	1.02	50.93
Feb	6.00	914	4.20	3838.80	1.65	462.00	0.1204	1.82	53.76
Mar	3.70	914	4.10	3747.40	1.80	504.00	0.1345	1.03	48.10
Apr	20.57	920	4.70	4324.00	2.00	560.00	0.1295	5.14	49.95
May	36.05	923	4.40	4061.20	2.15	602.31	0.1483	8.38	43.62
Jun	402.44	930	6.30	5859.00	5.55	1554.00	0.2652	36.27	24.39
Jul	1660.86	930	6.50	6045.00	6.20	1736.00	0.2872	133.99	22.53
Aug	994.38	930	6.40	5952.00	5.80	1624.00	0.2728	85.76	23.71
Sep	1879.00	930	6.50	6045.00	6.20	1736.00	0.2872	151.59	22.53
Oct	308.85	929	6.30	5852.70	4.20	1176.00	0.2009	36.78	32.20
Nov	214.07	928	6.20	5753.60	3.85	1078.00	0.1874	27.81	34.53
Dec	46.00	923	4.40	4061.20	2.30	644.00	0.1586	10.00	40.80

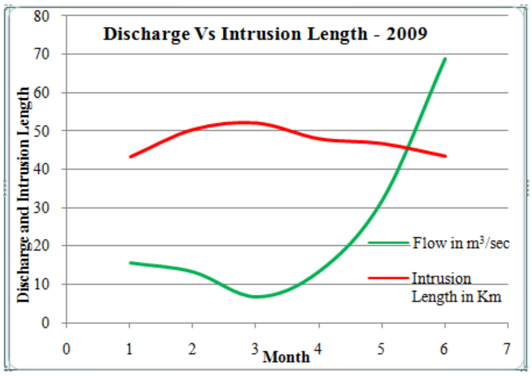

Fig 2 Month Wise Discharge and Salinity Intrusion Length for year 2009

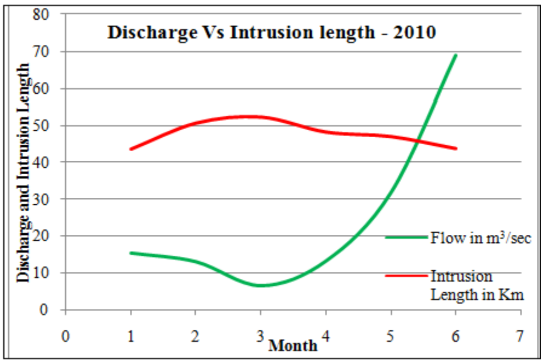

Fig 3 Month Wise Discharge and Salinity Intrusion Length year 2010

Once the salinity is withdrawn to a level, it was maintained through a particular fresh water discharge. But the small variations are due to some other factors, like tidal variations etc as mentioned earlier. The highest salinity traced in this year also during the month of February, when there was least fresh water discharges when there was least fresh water discharges as shown in Fig 2. The study results reiterated about the monsoon factors and its dependability during monsoon. This year study results also repeats that the salinity intrusion length is around inversely proportional to the fresh water discharges through the estuaries.

International Journal of Advance Research in Science and Engineering
Vol. No.4, Issue 10, October 2015
www.ijarse.com
IJARSE
ISSN 2319 - 8354

Table 4 Computation of Salinity Intrusion Length during 2010

A	B	C	D	E	F	G	H	I	J
Jan	18.66	916	4.30	3938.80	1.80	504.00	0.128	5.19	50.56
Feb	20.93	920	4.30	3956.00	1.70	476.00	0.1203	6.16	53.77
Mar	26.38	920	4.30	3956.00	1.90	532.00	0.1345	6.95	48.11
Apr	23.17	920	4.30	3956.00	1.80	504.00	0.1274	6.44	50.78
May	35.78	921	4.40	4052.40	2.20	616.00	0.1520	8.14	42.56
Jun	353.18	930	6.30	5859.00	5.60	1568.00	0.2676	31.55	24.17
Jul	511.99	930	6.10	5673.00	5.80	1624.00	0.2863	44.15	22.60
Aug	422.89	930	5.90	5487.00	5.40	1512.00	0.2756	39.17	23.48
Sep	329.60	930	5.00	4650.00	7.80	2184.00	0.4697	21.14	13.77
Oct	597.44	930	5.10	4743.00	3.40	952.00	0.2007	87.89	32.23
Nov	375.39	930	5.20	4836.00	3.20	896.00	0.1853	58.68	34.92
Dec	149.32	920	4.60	4232.00	2.40	673.27	0.1591	31.06	40.67

Table 5 Flow and Salinity Intrusion Length

	2008		2009		2010	
Mon	Fresh Water Discharg	Salt Water Intrusion Length, XL	Fresh Water Discharge,	Salt Water Intrusion Length, XL	Fresh Water Discharg	Salt Water Intrusion Length, XL
Jan	13.24	50.56	3.48	50.93	18.66	50.56
Feb	6.76	52.23	6.00	53.76	20.93	53.77
Mar	13.42	48.11	3.70	48.10	26.38	48.11
Apr	31.91	46.87	20.57	49.95	23.17	50.78
May	68.84	43.58	36.05	43.62	35.78	42.56
Jun	212.96	24.17	402.44	24.39	353.18	24.17
Jul	475.88	22.55	1660.86	22.53	511.99	22.60
Aug	489.34	21.10	994.38	23.71	422.89	23.48
Sep	1069.91	22.24	1879.00	22.53	329.60	13.77
Oct	303.12	26.07	308.85	32.20	597.44	32.23
Nov	256.17	29.17	214.07	34.53	375.39	34.92
Dec	15.61	43.40	46.00	40.80	149.32	40.67

In regard to the year 2010, the salinity intrusion length varies between 13.77 for the month of September, and 53.77 for the month of February. As per Table 4, in this year also the lowest salinity recorded not for the highest fresh water discharge month. This gives a clear indication that the salinity will recede to a low level in the initial wash up of salinity due to monsoon flow and can maintain the low level till another intrusion occurs due to poor fresh water discharges. The small variation in salinity intrusion is seen in this year also due to the expected factors mentioned earlier. February month records the highest salinity for this year also as the fresh water discharges was low in the year. The study results of year 2010 depict vide Fig 3, also replicate that the salinity intrusion length is almost inversely proportional to the fresh water discharges through the estuaries.

The flow and salinity intrusion for the years 2008, 2009 and 2010 for Periyar River estuaries have been worked out using Brockway Model as per Table 5. The study results give clear indication that the salinity intrusion length is inversely proportional to the fresh water discharges.

IV. CONCLUSION

1. The Salinity Intrusion length was computed using Brockway Model and found that the Intrusion Length is inversely proportional to the estuarine river discharges.
2. The Brockway Model was tested using the measured Salinity to obtain the Salinity Intrusion Length.
3. The intrusion lengths obtained by the Brockway model are assisting to predict the salinity concentration at head works.
4. The study results will assist for a better flow control so as to maintain the water supply scheme uninterrupted.
5. The study results will assist for the betterment of other water users like agricultural and industrial purposes.

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