International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2013 Vol.3 (2) May-August, pp.153-161/Prabhakaran and Resmi
Research Article

PERIYAR RIVER FLOW AND KOCHI WATER SUPPLY SCHEME - A COMPARISON OF MASS BALANCE AND MEASURED VALUES

***Prabhakaran M.M.[1] and Resmi G.[2]**
[1]*Civil Engineering Department, Karpagam University, Coimbatore, India*
[2]*Civil Engineering Department, N.S.S. College of Engineering, Palakkad, India*
**Author for Correspondence*

ABSTRACT
A river is a natural watercourse, usually freshwater, flowing towards an ocean, a lake, a sea, or another river. Considering a dictionary definition, hydrology is simply the scientific study of water or water processes, which may include various characteristics or components, such as control, conservation, flooding, pollution, storage, etc. As a result, there are many research pathways that are contained within the study of hydrology, and the most fundamental and direct discipline is the study of stream flow. Periyar has been performing a pivotal role in shaping the economic prospects of Kerala, as it helps in power generation, domestic water supply, irrigation, tourism, industrial production, collection of various inorganic resources and fisheries. A huge quantity of water simply discharged to the sea during monsoon and facing acute scarcity during summer. This calls for the proper conservation and efficient management of water resources. Thus, a proper evaluation of the river flow considering all possible inflows, losses, withdrawals and unutilized discharges are considered. The major inflow is through the runoff was calculated using Curve Number method. The validity of the method adopted for Mass Balance Calculation was checked with measured values at an intermediate station.

Key Words: *Continuity equation, Inflows, Mass balance, River system, Withdrawals*

INTRODUCTION
A river is fresh water flowing across the surface of the land, usually to the sea, it flows in a channel. The bottom of the channel is called the bed and the sides of the channel are called the banks (Czaja, 2005). Rivers are the main sources for drinking water and irrigation, and of course, it provides us with food, energy, recreation, transportation routes. We can say rivers are the vein and sinew of the earth. Rivers begin in mountains or hills, where rain water or snowmelt collects and forms tiny streams called gullies. Gullies either grow larger when they collect more water and become streams themselves or meet streams and add to the water already in the stream. When one stream meets another and they merge together, the smaller stream is known as a tributary. The two streams meet at a confluence. It takes many tributary streams to form a river. A river grows larger as it collects water from more tributaries. Streams usually form rivers in the higher elevations of mountains and hills.

Hydrology
If we go for a scientific study of water or water processes, which may include various characteristics or components, such as control, conservation, flooding, pollution, storage, etc. As a result, there are many research pathways that are contained within the study of hydrology, and the most fundamental and direct discipline is the study of stream flow (Shikolomanov, 2007). The main source of Kochi Drinking Water Supply is River Periyar, which undergoes the above mentioned factors and scenario, giving importance of this study.

Periyar River
The River Periyar, the longest river of Kerala state is considered to be the life line of Central Kerala. Periyar has been performing a pivotal role in shaping the economic prospects of Kerala, as it helps in power generation, domestic water supply, irrigation, tourism, industrial production, collection of various inorganic resources and fisheries.

To meet all the needs and for future demands, this river is to be managed properly. Water Supply management involves controlling the supply and distribution of available water as designed, and monitoring its quality. In places where there are persistent water shortages, managing the supply may also mean rationing water so that it is available to those who need it most.

Problem Statement

Kochi is considered as the commercial capital of Kerala State. Periyar River is the main source of drinking water to Kochi area. Like any other rivers in India, this river is also abused and its intensity increasing day by day due to human and other activities for our modernity. A huge quantity of water simply discharged to the sea during monsoon and facing acute scarcity during summer. This calls for the proper conservation and efficient management of water resources. Thus, a proper evaluation of the river flow is essential, hence this study.

Objectives

1. To Conduct a Mass Balance study of Periyar River from the Barrage Bhoothathankettu to the Estuaries.
2. To study the monthly variation in final fresh water out flow to the Arabian Sea at (estuaries) Purapillikavu and Eloor.
3. To Compare the Mass balance output with the Measured values of Flow and its validity using statistical methods

MATERIALS AND METHODS

Mass balance Study

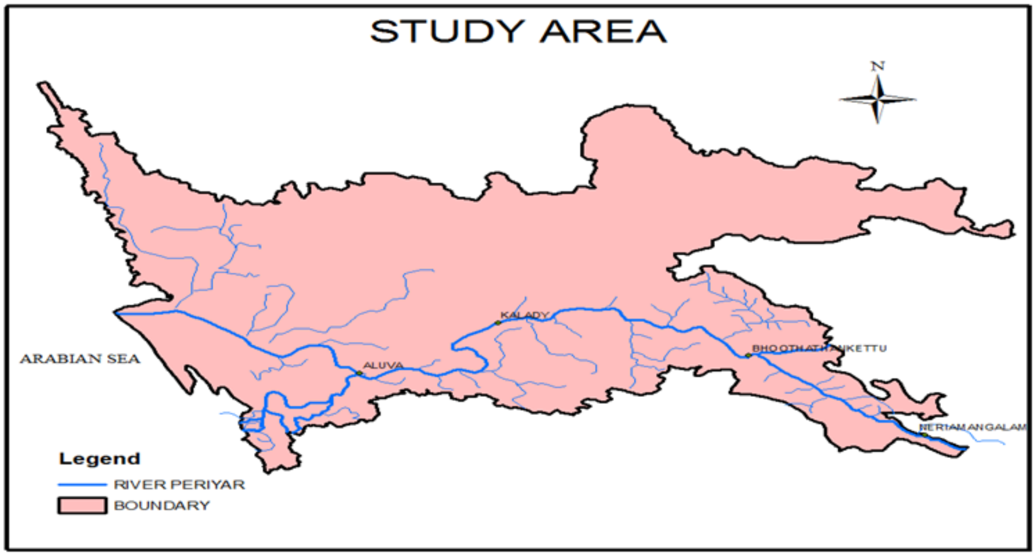
In any process, the equation of continuity can be taken as its basis. In the case of river flow, the equation of continuity can be applied; as there are many ways of inputs to the river in the form of discharge from barrage, runoff, tributaries, and discharge from various industries, individual houses, Hotels and municipal drains. There can be losses like evaporation, seepage and evapo-transpiration (Muthukrishnan, 2006; Pradhan *et al.,* 2010). Before the final discharge into sea, required beneficial users will use or exploit its maximum strength. The sum of the total losses, utilization by beneficial users and the final discharge will be equal to the sum of inputs (inflows). Even though the Mass Balance Study (Czaja, 2005) in a physical system like river is most complicated with heterogeneous input data, which may require in depth studies, the results will be useful for planning for various river management works. The following step by step Procedure is adopted for the study.

(a) Calculation of Run Off using CN Number Method, (b) Calculated the monthly discharge of Barrage from the daily discharges computed from the details of barrage shutter openings, (c) Based on Step 1 and by convenience, the Study area of the river divided into 7 stretches, (d) The discharges from various industries are to be tabulated separately, (e) Now the total inflow (Qi) to the first stretch can be computed from the sum of the Barrage discharges, Runoff and the discharges from various industries, (f) Calculate the withdrawals by Various organisations viz; KWA, WR, Industries and by individuals, (g) Now Calculate the total Withdrawals (Qw) after considering the seasonal variations, (h) Compute the Out flow (Qo) from the first stretch, (i) Out flow of the 1st stretch will be the inflow to the 2nd stretch in addition to the runoff and discharges in the 2nd stretch to compute the total inflow to the 2nd stretch, and (j) Now continue the steps (f), (g), and (h) till Nth stretch outflow (No). Further, the Validation of the above Mass Balance work can be verified using the measured values

RESULTS AND DISCUSSION

The Daily Runoff recorded at Bhuthathankettu was obtained. Runoff in m3/day of each raster was computed and thereby the accumulated runoff in m3/day of each water shed was calculated. The corresponding water sheds of the sections were identified and the total runoff (r_f) to the section was computed in m3/month.

International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2013 Vol.3 (2) May-August, pp.153-161/Prabhakaran and Resmi
Research Article



Figureure 1: Study Area

Table 1: Details of Sections and the Related Water Sheds with Sub water Sheds

Sl No	Name of Station	Section Code	Location	Average Width (m)	Average Depth (m)	Distance From Dam (km)
1	*Bhoothathankettu*	BH	10°2'6"N 76°39'50.4"E	230.00	2.00	0
2	*Vengoor (near)*	VG	10°10'19.2"N 76°34'4.8"E	113.30	2.00	15.1
3	*Kalady*	KA	10°09'54"N 76°26'34.8"E	114.11	4.00	30.2
4	*Vallom*	VL	10°10'19.2"N 76°34'4.8"E	115	3.5	42.3
5	*Chowara*	CW	10°6'21.6" N 76°23'26.65" E	200	2.5	50
6	*Aluva*	AV	10°6'21.6" N 76°23'26.65" E	340.00	3.50	64.1
7	*Purapillikavu*	PU	10°08'34.48" N 76°17'03.17" E	450.00	4.00	82.5
8	*Eloor*	EL	76°18'30.27" E 10°04'52.84" N	111.00	2.00	75.4

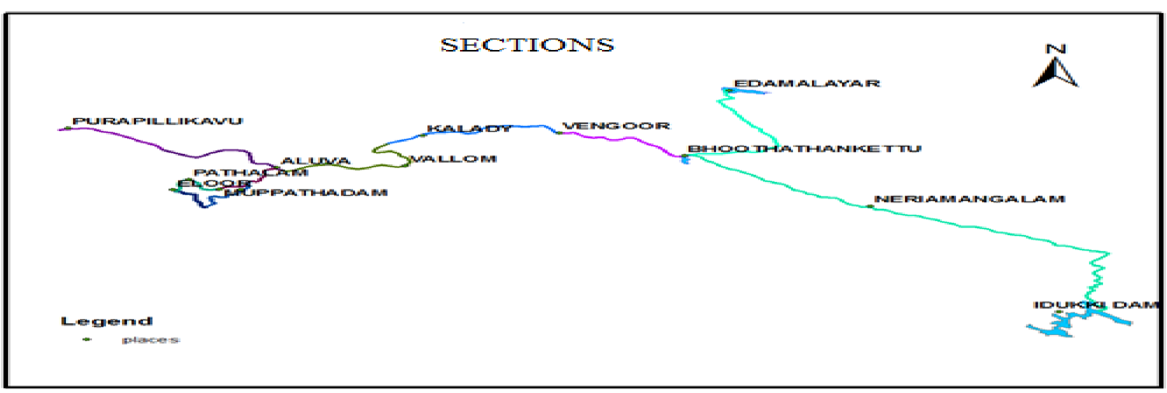


Figure 2: Section Wise Details

Table 2: Section Wise Monthly Runoff in m^3 for the Year 2004

Month	BH-VG	VG-KA	KA-VA	VA-CH	CH-AV	AV-PU	AV-EL
Jan	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0
Mar	350357	293477	107403	225262	33727	8272083	2369153
Apr	760636	985906	440527	359648	90184	12881662	2266447
May	2292614	2582409	1094144	1257972	253465	45704991	10599393
Jun	10892101	13640926	6202983	4550788	1218454	160572284	23481676
July	4981125	5881038	2700068	1965564	518550	71128444	11675105
Aug	18742763	21880652	10374596	5773052	1837664	206068943	20627836
Sept	155108	118140	41234	100810	14165	3817258	1251183
Oct	6670858	8528950	3845760	2948014	770908	103074632	15243351
Nov	15904	296	0	23562	2	1742942	1016560
Dec	0	0	0	0	0	0	0

Barrage Discharge

The daily discharge in m3 from the Barrage was calculated based on the details of shutter openings. From the details of daily discharge, the monthly discharge (q_b) in m3 and the discharge in m3/sec are to be computed.

Table 3: Details of month wise 2004 discharge from barrage

Month	m^3/month	m^3/sec	Month	m^3/month	m^3/sec	Month	m^3/month	m^3/sec
Jan	53235000	19.88	*May*	95495000	35.65	*Sep*	796127000	307.15
Feb	31741000	12.67	*Jun*	363742000	140.33	*Oct*	1.591E+09	593.83
Mar	24895000	9.29	*Jul*	628673000	234.72	*Nov*	409982000	158.17
Apr	110046000	42.46	*Aug*	1527430000	570.28	*Dec*	26041000	9.72

Discharge from Industries and Flats

Details of industries are obtained. Its consumption details and discharge pattern including quantity (q_i) are noticed. The discharge in section wise is computed.

Table 4: Month Wise Industrial Discharge for the year 2004 in m^3/sec

Section No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	*BH-VG*	0	0	0	0	0	0	0	0	0	0	0	0
2	*VG-KA*	65.24	2.6E-05	9.7E-12	4E-18	1E-24	5E-31	2E-37	8E-44	3E-50	1E-56	4E-63	1.6E-69
3	*KA-VL*	199.49	8E-05	3E-11	1E-17	4E-24	2E-30	6E-37	2E-43	9E-50	3E-56	1E-62	4.8E-69
4	*VL-CW*	21.63	8.6E-06	3.2E-12	1E-18	5E-25	2E-31	7E-38	2E-44	1E-50	4E-57	1E-63	5.2E-70
5	*CW-AV*	237.88	9.5E-05	3.5E-11	1E-17	5E-24	2E-30	7E-37	3E-43	1E-49	4E-56	2E-62	5.7E-69
6	*AV-PU*	36.96	1.5E-05	5.5E-12	2E-18	8E-25	3E-31	1E-37	4E-44	2E-50	6E-57	2E-63	8.9E-70
7	*AV-EL*	39332.56	0.0157	5.9E-09	2E-15	8E-22	3E-28	1E-34	5E-41	2E-47	7E-54	3E-60	9.4E-67

Table 5: Month Wise Discharges from Flats for the year 2004 in m^3/sec

Section No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	*BH-VG*	0	0	0	0	0	0	0	0	0	0	0	0
2	*VG-KA*	0	2.6E-05	9.7E-12	4E-18	1E-24	5E-31	2E-37	8E-44	3E-50	1E-56	4E-63	2E-69
3	*KA-VL*	162.41	8E-05	3E-11	1E-17	4E-24	2E-30	6E-37	2E-43	9E-50	3E-56	1E-62	5E-69
4	*VL-CW*	102.95	8.6E-06	3.2E-12	1E-18	5E-25	2E-31	7E-38	2E-44	1E-50	4E-57	1E-63	5E-70
5	*CW-AV*	705.69	9.5E-05	3.5E-11	1E-17	5E-24	2E-30	7E-37	3E-43	1E-49	4E-56	2E-62	6E-69
6	*AV-PU*	660.84	1.5E-05	5.5E-12	2E-18	8E-25	3E-31	1E-37	4E-44	2E-50	6E-57	2E-63	9E-70
7	*AV-EL*	901.09	0.0157	5.9E-09	2E-15	8E-22	3E-28	1E-34	5E-41	2E-47	7E-54	3E-60	9E-67

Research Article

Total Discharge

Total discharge to the first section is the sum of the discharges from the barrage, runoff from the section and industrial discharge of the section. This will be known as the inflow (Qi) of first section. Likewise, the sum of the discharges of all sections will provide the total discharge of the system under consideration.

Withdrawals and Losses

Various agencies are withdrawing water from Periyar River; mainly by (1) Kerala Water Authority (Drinking Purpose), (2) Water Resources Department (Irrigation Purpose), (3) Industries (Industrial Purpose- Depends on the nature and industry, and; (4) Individuals (Multipurpose & nature- Domestic to Industrial).

Withdrawal points (Intakes) from the Barrage to the Estuary including the capacity of withdrawal on either side of the river are marked in the map using GIS. The withdrawal points of all Schemes related to KWA, WR, Industries and Individuals to the maximum possible extend up to a daily withdrawal not less than 5 kilo litres. Sum of these withdrawals to the first section is known as (Qw). Similarly, withdrawals up to the nth section are computed.

Withdrawal by Kerala Water Authority

Table 6: Month Wise Withdrawal Details of Kerala Water Authority in m^3/Sec

Sec. No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*BH-VG*	0.12	0.11	0.12	0.11	0.12	0.11	0.12	0.12	0.11	0.12	0.11	0.12
2	*VG-KA*	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3	*KA-VL*	0.09	0.08	0.09	0.08	0.09	0.08	0.09	0.09	0.08	0.09	0.08	0.09
4	*VL-CW*	1.10	1.03	1.10	1.07	1.10	1.07	1.10	1.10	1.07	1.10	1.07	1.10
5	*CW-AV*	2.69	2.52	2.69	2.60	2.69	2.60	2.69	2.69	2.60	2.69	2.60	2.69
6	*AV-PU*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	*AV-EL*	0.96	0.90	0.96	0.93	0.96	0.93	0.96	0.96	0.93	0.96	0.93	0.96

Withdrawal by Water Resources Department

Table 7: Month Wise Withdrawal Details of Water Resources Department in m^3/Sec

Sec. No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*BH-VG*	0.269	0.25	0.27	0.26	0.27	0	0	0.11	0.11	0.1	0.17	0.17
2	*VG-KA*	2.557	2.39	2.56	2.47	2.56	0	0	1.09	1.06	1.1	1.59	1.64
3	*KA-VL*	2.215	2.07	2.22	2.14	2.22	0	0	0.95	0.92	0.9	1.37	1.42
4	*VL-CW*	1.342	1.26	1.34	1.3	1.34	0	0	0.57	0.55	0.6	0.73	0.76
5	*CW-AV*	0.223	0.21	0.22	0.22	0.22	0	0	0.10	0.09	0.1	0.14	0.14
6	*AV-PU*	1.555	1.45	1.56	1.5	1.56	0	0	0.68	0.65	0.7	0.96	1.00
7	*AV-EL*	1.779	1.66	1.78	1.72	1.78	0	0	0.75	0.73	0.8	1.09	1.13

Withdrawal by Industries

Table 8: Month Wise Withdrawal Details of Industries in m^3/Sec

Sec. No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*BH-VG*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	*VG-KA*	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
3	*KA-VL*	0.013	0.012	0.013	0.012	0.013	0.012	0.013	0.013	0.012	0.013	0.012	0.013
4	*VL-CW*	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
5	*CW-AV*	0.015	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
6	*AV- PU*	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
7	*AV-EL*	2.520	2.357	2.520	2.439	2.520	2.439	2.520	2.520	2.439	2.520	2.439	2.520

Withdrawal by Flats / Apartments

Table 9: Month Wise Withdrawal Details of Flats/ Apartments in lps

Sec. No	Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	*BH-VG*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	*VG-KA*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	*KA-VL*	6.28	5.87	6.28	6.08	6.28	6.08	6.28	6.28	6.08	6.28	6.08	6.28
4	*VL-CW*	3.82	3.57	3.82	3.69	3.82	3.69	3.82	3.82	3.69	3.82	3.69	3.82
5	*CW-AV*	28.30	26.48	28.30	27.39	28.30	27.39	28.30	28.30	27.39	28.30	27.39	28.30
6	*AV-PU*	24.76	23.16	24.76	23.96	24.76	23.96	24.76	24.76	23.96	24.76	23.96	24.76
7	*AV-EL*	30.87	28.88	30.87	29.88	30.87	29.88	30.87	30.87	29.88	30.87	29.88	30.87

Outflow

Out flow of the section is the net available quantity after all withdrawals and losses from the inflow of the section. This concept is represented through the Figureure given below and is continued up to the nth section of the river for the Mass Balance study of the river. It can be expressed as

Qin – Qw – Ql = Qo............... (3.1)

Where, Qin = Q inflows, Qw = Q withdrawls, Qo = Q outflows

Inflows to a river includes flow from the reservoir, Runoff from the watersheds, discharge from industries etc. Runoff is the main component contributing significantly to the river flow. Withdrawals include water taken by KWA, irrigation department and by industries. Losses includes Evapo-transpiration loss, seepage loss etc.

Similarly, consider the entire stretch of river. The length of this portion can be divided into ‘n’ sections conveniently. The outflows from each section will be the net result of the inflows and losses. When considering the first section, the outflow from the first section can be calculated as per equation (3.2). The outflow from the first section is taken as the inflow to the next section. The entire stretch of the river is analysed in the same manner. The process can be expressed as follows.

Qin1 – Qw1 – Ql1 = Qo 1 (3.2) Qo1 = Qin 2,

Qin2 – Qw2 – Ql2 = Qo2 (3.3) Qo2 = Qin 3,

. . . = Qo (n-1) Qo (n-1) = Qin (n)

Qin (n) – Qw (n) – Ql(n) = Qo(n) (3.4)

The outflow from the final section (n^{th} section) will be the final fresh water outflow to the sea. Table (4) describes the section details for the study. The Periyar River has been divided into 7 sections, Table (1) from the Bhoothathankettu Barrage towards the two estuaries (Purapillikavu and Eloor).

Mass Balance Calculations

Let us consider the river as a whole Figure (2). The water released from the barrage is the main inflow to the river downstream. As the water flow downwards, various tributaries will be joining along the course of river till it finally meets with the Arabian Sea. Along the banks of the river various organization like Kerala Water Authority, Water Resources department, are withdrawing water for water supply and for irrigation purposes. Flats, Apartments, and private firms located nearby are also using the river water for domestic and other purposes. So certain amount of water will be lost. The industries located at the downstream discharges effluents to the river thereby reducing the fresh water amount. The fresh water amount reaching the estuary should be sufficient to overcome the salinity intrusion towards upstream. When this study is integrated into a mass balance method, the calculations can be represented as equation (3.4). Based on the above mentioned method, by applying the continuity equation, the flow at every point can be calculated.

Research Article

The water balance study from 2001 to 2010 was conducted and the details of discharge at Kalady both by Mass balance study and Measured is computed. Its S, R and R2 values for these years are tabulated in Table 13, below.

Table 10: Month wise flow details in m^3/ sec during 2004

Station	Distance	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BH	0.0	19.9	13.1	9.3	42.5	35.7	140.3	234.7	570.3	307.1	593.8	158.2	9.7
VG	13.3	19.5	12.8	9.0	42.2	35.6	142.2	235.6	574.4	306.9	594.7	157.9	9.4
KA	29.7	17.9	10.9	7.4	40.9	34.9	147.5	237.8	581.6	305.9	596.8	156.3	7.9
VL	36.5	16.5	9.3	6.0	39.5	33.7	149.1	238.4	583.3	304.9	596.9	155.0	6.6
CW	44.4	15.6	8.4	5.2	38.7	33.2	150.1	238.6	584.4	304.3	597.1	154.2	5.8
AV	49.0	13.3	5.8	2.9	36.4	31.1	148.6	236.8	583.2	301.9	595.3	151.8	3.5
PU	69.8	5.7	1.7	3.4	22.6	31.9	138.5	149.3	378.4	157.7	346.8	78.5	0.8
KM	56.0	6.4	2.8	2.2	18.2	18.4	79.3	117.5	286.7	145.4	290.8	73.2	1.7
EL-1	65.6	1.5	0.7	1.5	5.4	8.8	29.2	33.4	78.3	36.0	77.1	18.3	0.4
MU	56.0	3.5	0.6	1.5	13.6	17.8	72.0	94.6	226.2	109.7	226.6	54.6	0.1
PA	59.7	3.1	0.2	1.9	14.0	21.1	80.1	98.3	233.0	109.7	231.5	54.6	-0.3
EL-2	65.4	2.9	0.0	2.5	14.6	24.4	87.7	102.0	239.5	110.1	236.3	54.8	-0.4
ELT	65.7	4.5	0.7	4.0	20.0	33.2	117.0	135.4	317.8	146.0	313.4	73.1	0.0

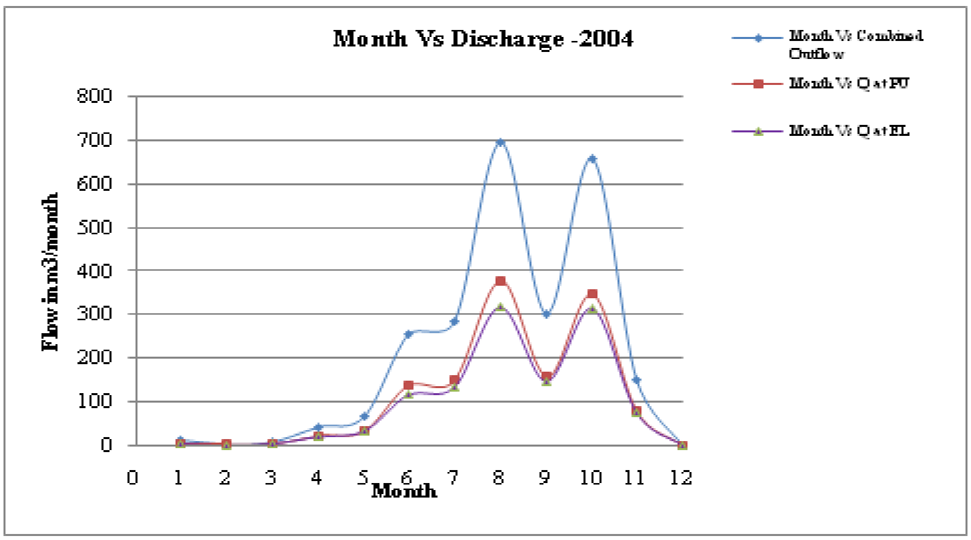


Figure 3: Discharge at Kalady -2004 (Measured- WRD) Vs Mass Balance Calculation

Table 11: Mass balance work- flow details at Kalady in m^3/ sec (From 2001 to 2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2001	20	10	14	42	58	202	451	463	1074	261	246	25	239
2002	16	11	20	12	60	200	1319	914	852	787	213	9	368
2003	15	13	2	42	18	75	1305	864	961	740	295	50	365
2004	18	11	7	41	35	147	238	582	306	597	156	8	179
2005	5	9	4	11	28	123	1614	2141	2740	671	476	86	659
2006	4	21	30	31	146	386	1013	882	405	867	737	99	385
2007	25	10	11	49	28	267	1730	64	1591	988	1085	56	492
2008	21	9	13	39	60	195	375	415	1037	263	263	23	226
2009	11	14	4	25	22	370	1581	898	1823	269	203	45	439
2010	24.1	29.4	33.9	28.6	33.5	193.9	458.6	344.3	305.57	530	305.1	156	204

Table 12: Measured flow details at Kalady in m^3/ sec (From 2001 to 2010)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2001	29	14	16	51	62	321	550	551	977	292	273	17	263
2002	25	16	35	19	91	165	1140	809	905	878	249	16	362
2003	22	23	21	63	21	85	1399	912	1037	769	313	73	395
2004	32	32	28	52	48	174	255	732	324	598	163	53	208
2005	6	12	19	21	38	198	1191	1673	1964	815	497	132	547
2006	10	26	35	32	176	386	1020	902	412	939	741	101	398
2007	41	43	72	55	102	499	1499	68	1759	1006	1089	64	525
2008	48	17	60	141	156	160	449	450	945	254	255	31	247
2009	29	17	9	29	35	267	1739	829	1756	325	227	62	444
2010	51	35	38	41	43	217	521	350	294	339	383	154	205

Table 13: Statistical Relationship between Mass balance Flow and Measured Flow

Year	Std Error 'S'	Coefft. of Correlation 'r'	Coefft. of Regression 'r2'	Year	Std Error 'S'	Coefft. of Correlation 'r'	Coefft. of Regression 'r2'
2001	56.49	0.9834	0.9671	2006	19.44	0.9989	0.9978
2002	65.48	0.9896	0.9793	2007	110.43	0.9864	0.973
2003	11.41	0.9997	0.9994	2008	45.99	0.9862	0.9726
2004	37.14	0.9887	0.9775	2009	69.97	0.9947	0.9894
2005	103.06	0.9902	0.9806	2010	64.35	0.9319	0.8684

CONCLUSION

- Mass balance Study gives the discharge at any point or section
- The Study reveals the quantity of unused discharges through Estuaries.
- The study details can be used to control the flood as well as drought
- The results obtained through the Mass balance were validated with measured discharges and found that it has got a strong linear relationship.
- The mass balance study details can be utilized for the proper River Management.
- A control over the beneficial users can be established for limiting their consumptions/ withdrawals.
- Unauthorised withdrawals and discharges from the industries can be identified for proper actions
- By noticing the discharges, the industry can be identified and necessary remedial measures can be taken to control the river Pollution
- An early action can be taken to protect the drinking water source for lifting the designed quantity of water for an uninterrupted drinking water supply.
- The methodology can be used for future planning as well as for other river management systems also on similar conditions or by applying the changing conditions for better applications.
- The validation of the study gives more strength for modelling the River.

REFERENCES

Trommer JT *et al.*, (1996). Evaluation And Modification Of Five Techniques For Estimating Stormwater Runoff For Watersheds In West-Central Florida, Water-Resources Investigations Report 96–4158.

Blee JWH (2006). Central Water Commission Basin Planning and Management Organisation Evaporation Control in Reservoirs, Government of India New Delhi.

Metcalf and Eddy (1990). Waste Water Engineering Treatment Disposal Reuse, Revised by George Techobanoglous, TATA McGraw-Hill **II.**

Ratika Pradhan *et al.,* (2010). Estimation of Rainfallrunoff Using Remote Sensing and GIS in and Around Singtam East Sikkim, *International Journal of Geomatics and Geosciences* 1(3).
Shikolomanov (2007). Temporal and Special variation in maximum river discharge from a new Russian data set, *Journal of geophysical research* **112**.
Stanislaw Czaja (2005). Changes in Rivers Discharge Structure and Regime in Minning- Industrial-Urban Areas,) *Article, Reg Environ Change* (2005) **5** 18–26 Springer-Verlag.
Suresh Muthukrishnan (2006). Calibration of A Simple Rainfall-Runoff Model for Long-Term Hydrological Impact Evaluation, *URISA Journal* **18**(2).