ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

ENVIRONMENTAL FLOW REQUIREMENT OF GODVARI RIVER BY TENNANT'S METHOD

SAURAV ANAND 1 , VIKAS SINGH 2

NATIONAL INSTITUTE OF TECHNOLOGY ANDHRA PRADESH

DEPARTMENT OF CIVIL ENGINEERING

Abstract:- Environmental flow is great significance for maintenance of ecological services in the riverine ecosystem. Development of surface -water resources in river basin for agriculture ,urban use ,hydropower, industrial use and such other uses beneficial to human as well world or environment .Recent awareness of environmental and ecological aspect of our planet has to led to development as well as conservation water resources. The flow of many rivers has been reduced or seasonally altered changing of size and frequency of flood. It is also affected by length as well severity or droughts. The ecosystem of some of the rivers have been so severely and adversely impacted that they appear to be beyond redemption. It is estimated that over one half of the world's major river system are presently adversely affected by flow regulation.

KEY WORD:- EF(Environmental flow), EFR (Environmental flow requirement) ,EFA(Environmental flow Assessment), MFR(Mean flow rate),

HFS(High flow Season), LSF(Low Flow Season).

Introduction:-Environmental flows in a system for managing the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystem and the human livelihoods and well being that depend on these ecosystems. A consequence of a this awareness is the concept of environmental flows of a river. The World Bank defines the Environmental flows (EF) as : The quality ,quantity and timing of water flows required to maintains the components, functions, processes and resilience of aquatic eco system which provided goods and services to people. The river ecosystem include not just the flora and fauna that lives in the river but also that lives in flood plains and wetlands supported by the river floods. It is seen that EF Only depends upon three important components : quantity ,variability and quality. These are not independent ,these are linked in all three components that together constitutes the EF. The variability aspect that EF stands not only single value of a flow for a given river.

The evolution of EF concept:- In the early parts of 1950s there was a massive construction activity of dams world over for irrigation and hydropower development. At

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

that time, practically ,no serious attention was paid to upstream and downstream environmental impacts and ecological damages to the riverine ecosystem were literally ignored. In 1960 some developed nations focused largely on maximizing flood protection ,water supplies and hydropower generations. During the 1970s the ecological and economics effects of these projects prompted scientists to seek ways to modify dam operations to maintains certain fish species. Initially, it was thought that a minimum flow in the stream would serve the purpose of maintaining quality of water in the river and ecological balance in the downstream of the river .The inadequacy of minimum flow to address the ecological concern adequately was recognised in early 1980s and the birth of the concept of environmental flows. In 1990s south Africa ,USA, UK and EU have adopted various appropriate legislations to bring the EF in to the mainstream. The world bank has adopted the EF as part of its mandatory component in their integrated water resources management (IWRM) activity related to all new water project. The concept of EF has been slow in India . But now the government is very conscious about the EF.

Essentials of environment flows:-

Environmental flows generate benefits for people and nature. An environment flow is the water regime provided within the river ,wetland or costal zone to maintain ecosystem and their benefits where there are competing water uses and where flows are regulated. Environmental flows provided critical contribution to river health ,economics development and many other factor.

1.Clear objectives and abstractions scenarios need to be defined:-To set an environmental flow one need to identify clear objectives as well as water abstraction and land use scenarios. Objective should have measurable indications that can form basis for water allocations. Objective and scenarios can be defined with multi-discipline expert team and stakeholder representatives.

2.Defining water requirement:-There is no sample figure that can be given for the environmental flow requirement of rivers ,wetlands and coastal areas. Environmental flow setting can best be done within the context of wider assessment frameworks that contribute to river basin planning . These frameworks are part of integrated water resource management and assess both the wider situations and river health objectives.

3. Modifying water Infrastructure:-Dams are often the most significant and direct modifiers of natural river flows .They are therefore an important starting point to implement environment flows. During the planning phase it is important to ensure that dam and reservoir operating strategies conform to environmental flow requirement .Many countries have a large stock of dams . the options for modifying release from these dams depend upon the type of dam ,the provisions for releasing water and the state of the key water control outlets and structures.

4. Covering the cost:-An analysis of the cost and benefits –including who gains and who loses-it is an important prerequisite for any decision on an environmental flow .Investment in environments flows will need to be justified by improvements in environmental ,social or economic conditions within the wider society .

5.Creating a policy and legal framework:-Only a limited number of countries have recognised the non-consumptive use of water and developed special domestics legislation to provide for it. So a legal and administrative pathway to

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

protect river flow is necessary before stakeholder will be willing to commit and agencies will be prepared to fund environmental flow project. Also international agreements and obligations form an important basis from which national polices and laws on environment flows can be developed.

6.Generating Political momentum:- Gaining the necessary momentum for establishing a regime for environmental flows will involve many different actors, from the highest levels of government right through to local communities and businesses. Communication and media are also vital role for making progress.

7.Building capacity for design and implementations:-environmental flows a relatively new issue for the water sector. Generally ,there is a lack of awareness throughout the sector and the general public of the concept and its application . Capacities need to be built amongst various actors to design and implement environmental flows.

Environmental flow Assessment:-

Environmental flow assessment (EFA) is the science of determining the quantity and quality of water required in a stream for its ecosystem conservation and resources protections .EFA tries to identify a environmental flow requirement flow requirement (EFR) of a stream at a given location that assure a reasonable healthy ecological condition of the river. Both spatial and temporal pattern of river are important. In a stream:-

1.High flows of different frequency are needed for breeding of birds, wetland flooding and riparian vegetation requirement .

2.Moderate level flows are critical for migrations of fish.

3. Minimum flows are important for water quality maintenance and for multipurpose uses of river by people and animals.

Thus , the EFR is not only minimum flow but also includes appropriate variability. In a reviews of international Environmental Flows assessment (EFA), Tharme (2003) recorded 207 different methodologies within 44 countries. He has classified the different methodologies in to four categories as:-

- Hydrological Index method
- Hydraulic rating methods
- Habitant simulation methodologies
- Holistic methodologies

Major advantage and disadvantage of different methodologies of EFA

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

Methodology	Duration of assessment	Major advantage	Major disadvantage
Hydrological index method	0.5	Low cost, rapid to use	Not truly site specific, Ecological links assumed
Hydraulic rating method	2-4	Low cost ,site specific	Ecological links assumed
Habitant simulation methodologies	6-18	Ecological links included	Extensive data collections ;needs experts ;high cost
Holistic methodologies	12-36	Covers most aspects	Requires very large scientific expertise; very high cost

(Source :- K Subramanya "Engineering Hydrology")

There are so many method are available for calculating the environmental flow requirement of riverbased on the different methodologies above already mention . One hydrologic rating method Known as Tennant's method is describe below and also compare with Flow duration curve of a given river.

Tennant's method:-This method was developed in USA in 1975. It was originally developed for protection of trout and is based on extensive field observations in mid-west of USA. This is based on percentage of mean annual flow (MAF) of a river. The method has undergone many changes and is used for general EFA purposes in many part of the world. In the method ,the water year is considered in two halves ,high flow season and low flow season. For each season , a certain flow ,expressed as a percentage of mean annual flow rate is prescribed to achieve a desired level of eco-system. The basic guidelines of Tennant for EFR are given below in fig 1.

Flow description of good habitant means that to achieve this level of eco status ,the basin managers must provided 40% of MAF rate during half year of high flow (April to September) and 20% of MAF rate during other half year of low flow (October through March). Further a flushing of 200% MAF rate for duration of 48 to 96 hours must be provided during High flow season.

Environment flow requirement by Tennant's method:-

Fig-1:-

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

Description of flow	Flow to released during	
	HFS(April to September)	LFS(October to March)
Flushing flow (from 48 to 96 hours)	200% MAF rate	Not applicable
Optimum range of flow	60-100 % MAF rate	60-100 % MAF rate
Outstanding habitat	60 % MAF rate	40% MAF rate
Excellent habitat	50% MAF rate	30 % MAF rate
Good habitat	40% MAF rate	20% MAF rate
Fair and degrading habitat	30% MAF rate	10% MAF rate
Poor or minimum habitat	10% MAF rate	10% MAF rate
Severe conditions	<10% MAF rate	<10 % MAF rate

MAF rate: -Mean Annual flow rate
HFS= High flow season of 6 months
LFS= Low flow season of 6 months

(Source :-K Subramany "Engineering Hydrology")

Flow Duration curve Method:-The flow duration curve (FDC) is cumulative frequency curve representing the percent of time during which the average discharge (Flow rate) equalled or exceeded a particular value at a given location. The FDC may be daily ,weakly or monthly value of a discharge. The streamflow data is arranged in the descending order of discharge. If N number of data points are used in the listing ,the plotting position of any discharge Q is

$$P= m/(N+1) *100\%$$

Where m is the order number of the discharge .P is a percentage probability of the flow magnitude being equalled or exceeded.

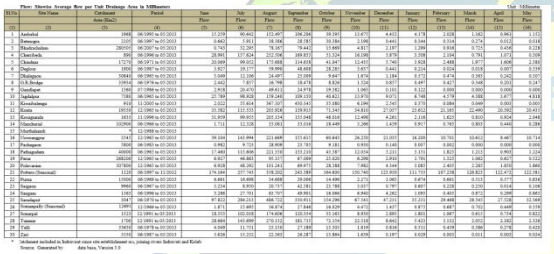
Many studied have reported Q_{95} and Q_{90} value highly inadequate to meet environmental flow requirement and even the growth of fishes.

CASE STUDY OF GODAVARI RIVER

Locations:- The Godavari river, the largest of the peninsular rivers and third largest in India ,covers drains about 10% of India's total geographical area. The catchment area of the river is 3,12,812 sq km and spread in the state of Maharashtra (48.6%), erstwhile Andhra Pradesh (23.4%),Madhya Pradesh (10.0%), Chhattisgarh (10.9%) ,Orissa (5.7%) and Karnataka(1.4%). The basin lies in the Deccan Plateau and is situated between latitude 16 16'north and 22 36' north and longitude 73 26'East and 83 07'East .The Godavari river rises in the Nasik district of Maharashtra about 80 km from the Arabian sea at an elevation of 1067m after flowing for about 1465 km in a generally south-east directions ,through Maharashtra and erstwhile Andhra Pradesh it falls into the Bay of Bengal. The basin is roughly triangular in shape and the main river itself runs practically along the base of the triangular.

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

Mean monthly flow in a Godavari river during 2012-2013:-



(Source:- Hydrological Data Directorate Information System organisation water planning & Project wing Central Water Commission New Delhi ,July2016)

From the above table mean monthly flow of Godavari river is as follow:-

Month	June	July	Aug	Sept	Oct	Nov
Mean monthly flow (cumec.day)	1770.693	6369.42	12337.78	9005.952	3672.26	1291.023
Month	Dec	Jan	Feb	March	April	May
Mean monthly flow (cumec.day)	900.829	715.046	550.578	615.430	589.065	643.950

Estimation of environmental flow required in the Godavari river to keep the desired ecological conditions by applying Tennant's method for a above data:-

Procedure:-

1.The mean annual flow (MAF) rate of the basin is obtained from the analysis the available stream flow data. Monthly or 10 daily values of an average water year are then assembled.

2.All the goods and services provided by the river at the study sketch, below the proposed impoundment or division locations ,are listed and current status .

3.Using Tenant's table , the monthly or 10 – daily flow throughout the year required to be released in the river is worked out. A flow hydrograph of the mean annual flow as well environmental flow requirement (EFR)are then prepared.

Calculations:-

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

Mean annual daily flow=38462.026/365= 105.375 cumec.day

Mean annual flow rate= MAF rate= 105.375 cumec.day

Flushing flow volume= 200% of MAF rate for 2 days =2*105.375

=210.375 cumec.day

For the good habitant conditions desired:-

- The high flow season (HFS) is from April to September and the EF is 40% of MAF rate.
  EFR volume in a month in HSF is calculated in col.4 as=col.2*105.375*0.4
- Similarly , the low flow season (LSF) is from October to March and the EF is 20% of MAF rate.
  EFR volume in LSF=col.2*105.375*0.2

Flushing flow volume of 210.375 cumec.day is provided in Auguest.

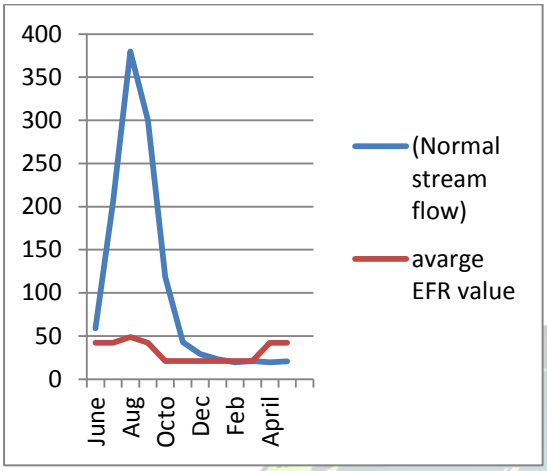
For the month of august ,flushing flow contributions an average rate of =210.375/31=6.786 cumecs.

Column 8 and 9 are used to plot the hydrograph of normal stream flow and EFR . The hydrograph are shown in below fig-

Month	No of day in month	Mean monthly flow volume in (cumec.day)	EFR (cumec.day) in a month		Flushing flows in the month (cumec. day)	Total EFR volume in the month (col.4+col.5+col.6)	Mean monthly flow rate (cumecs)	Average EFR rate in the month (cumecs)
			In HSF @ 40% of MAF rate	In LSF @20of MAF rate				
1	2	3	4	5	6	7	8	9
June	30	1770.69	1264.5			1246.5	59.02	42.15
July	31	6369.42	1306.6			1306.6	205.4	42.15
Aug	31	12337.3	1306.6		210.7	1517.3	397.9	48.94
Sept	30	9005.95	1264.5			1264.5	300.2	42.15
Octo	31	3672.26		653.3		653.3	118.5	21.08
Nov	30	1291.02		632.3		632.3	43.03	21.08
Dec	31	900.82		653.3		653.3	29.05	21.08
Jan	31	715.04		632.3		632.3	23.06	21.08
Feb	28	550.57		590.1		590.1	19.66	21.08
March	31	651.43		653.3		653.3	21.01	21.08
April	30	589.06	1264.5			1264.5	19.63	42.15
May	31	643.95	1306.6			1306.6	20.77	42.15
Total	365	38462.026						

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

Graph of discharge vs month of Godvari river:-

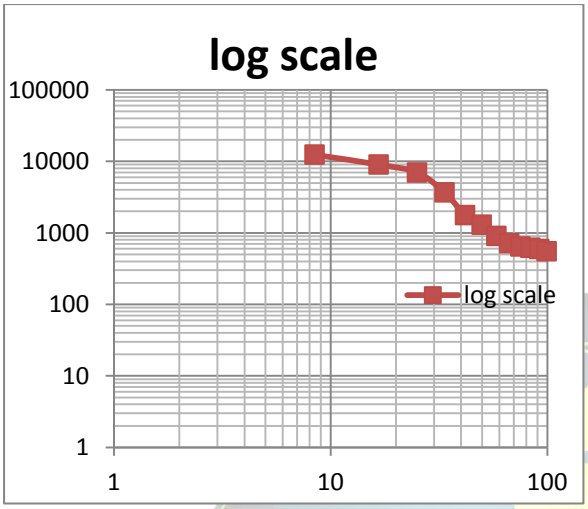


From FDC:- In frequency discharge curve , first arrange the data in descending order and the table as follow:-

Mean monthly flow(cumec.day)	Month name	No of days	Cumulative Total (m)	Pp =(m/N+1)*100%
12337.78	Aug	31	31	8.46
9005.952	Sep	30	61	16.67
6969.42	July	31	92	25.14
3672.26	Oct	31	123	33.60
1770.693	June	30	153	41.80
1291.023	Nov	30	183	50
900.829	Dec	31	214	58.46
715.046	Jan	31	245	66.93
643.95	May	31	276	75.40
615.43	March	31	307	83.87
589.065	April	30	337	92.07
550.578	Feb	28	365	99.72
			366	

ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 12, April 2018

From the above table the graph between Mean monthly flow and percentage time discharge as given below:-



From FDC method environmental flow requirements of Godavari river is Q_{95} and Q_{90}.

At Q_{95} = 19.144 cumecs and Q_{90} = 19.857 cumecs

Conclusion:-Thus Environmental flow requirement of Godavari River by Tennent's method gives more idea as compared to Flow Frequency curve method , because its gives the information about throughout the year. Also it also provides ranges of flow regime to maintain a single objective (river conditions). It is used in construction of the impoundment structure like reservoir ,dams etc..

References:-

1. Engineering Hydrology " K Subramanya".

2. Central Water Commission of India " http:// www.cwc .nic. in.>main>IHD2016_final ".

3.The essential of environmental flow by IUCN (The world conservation union) "http://www.waterandnature ".

4.Methodolologies for the Assessment environmental flows " Brij Gopal".