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Fresh Water Augmentation and Salinity Management in Kuttanad

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ABSTRACT
The Thanneermukkam bund was constructed to resolve the salinity problems faced by the farmers of Kuttanad; though it could reduce the problems to a large extend it had many ill effects such as water pollution, spread of aquatic weeds and other flora and fauna related problems. The main objective is to reduce the salinity level in Vembanad Lake during summer season that is during the closure period of Thanneermukkam Bund (TMB). The problem is solved efficiently by adapting following methods (1) water is taken from Muvattupuzha River, and conveyed through a regulator to Kuttanad region during summer season to dilute the water and keep the salinity below 2ppt and (2) water is collected in the *pazhnilam* before the closure of TMB and pumped out into Lake surrounding at times of acute shortage. The design of the regulator, its location and working is also discussed along with the various management techniques to be adopted in Kuttanad for effective implementation of the project. A proposal for management of water quantity and salinity for the natural water system of Kuttanad is developed.
Keywords– Augmentation, Kuttanad, Salinity Management.

I. Introduction

Kuttanad is known as the Rice Bowl of Kerala.It is one of the few places in the world where agriculture is practiced below sea level. It is a deltaic trough like formation shaped by the confluence of four major rivers of the State, the Meenachil, the Manimala, the Pampa and the Achenkoil draining into the Vembanad Lake. Its elevation ranges from 0.6m above to 2.2 metres below sea level. The area has a monsoon climate with a wet season from May to November and a dry season from December to April. The main problem faced by the region is the non availability of potable water in summer. During the monsoon seasons, the water from the mountains flow through the rivers to the sea, bringing potable water to Kuttanad. But during summer, due to the low level of the region, seawater enters Kuttanad and makes the salt content of the water high and making it unpotable.

During 1968, government of India proposed Thanneermukkam Salt Barrier project, in which a barrier will be made across the lake at Thanneermukkam so that seawater will not be allowed to come inside Kuttanad during summer, allowing farmers to cultivate an extra cycle per year.

Thanneermukkam salt-water barrier could prevent salt-water intrusion to Kuttanad to a major extend, but it caused other problems such as deterioration of water quality, spread of aquatic weeds and other environmental problems. At times the salinity slightly increases above the tolerance limit of paddy i.e. beyond 2ppt (parts per thousand). During the closure of the barrier in the dry season, the upstream area is no longer flushed by the tides and large scale consumption of water for paddy and domestic needs reduces the water level in the lake and thereby the water is highly polluted by pesticides & fertilizer residues from agricultural lands and by organic wastes dumped in to the Kuttanad waters. The water level depletion during the closure of the barrier is mainly due to the fact that there is no dry weather flow in the rivers draining in to Kuttanad.

II. Literature Review

Kuttanad Water Balance Study conducted by Netherlands proposed three measures to improve the problems faced in Kuttanad during summer of which one conclusion was that to divert the discharge in the Muvattupuzha River, which is fed by releases from the Idukki project and presently flow into the sea. It suggested the construction of two cross regulators one in each branch of the Muvattupuzha downstream of it's bifurcation close to the northern boundary if Kuttanad. The water will be diverted through existing water ways in the Vaikom area and along the eastern shore of Cochin lagoon to the Thanneermukkam barrior. It also suggested that low flow augmentation works were more economical and easier to implement than the protection works.

III. Methodology

Based on the study it is found that management of water quality in Kuttanad during the closure period of TMB is possible by making some small interventions in the hydrologic system.

1. Muvattupuzha River joins Vembanad Lake downstream of the Thanneermukkam Salt-water Barrier (TMB). This River receives about 1700mm^3/annum of Idukki tailrace discharge from Moolamattom. Since Idukki Hydro Electric project is a peaking station, the tailrace discharge is more in summer. Out of the total tailrace discharge of 1700mm^3, the discharge during December to May is about 950mm^3. After meeting the requirement of MVIP, HNL, GCDA, KWA the remaining water is let out in to the lake downstream of the TMB. Transferring part of this fresh water to the upstream of the TMB with some small interventions is possible.

Muvattupuzha River bifurcate into two branches Ithupuzha & Murinjapuzha before joining Vembanad Lake (Fig. 1). The southern branch, Ithupuzha is linked to the upstream of TMB through Vadayar thodu, Puthen thodu, Chirakkuzhi thodu, Kaipuzha ar & Pennar thodu. Regulators (permanent /temporary) are there in the links connected to the Vembanad Lake downstream of TMB. It could be seen flow is always there towards the Lake through Ithupuzha River and the water level fluctuates with respect to the tidal variation in the lake. Because of this effect one can seen that the flow in the Vadayar thodu is towards south during high tide and towards north during low tide. If a regulator is constructed across Vadayar thodu with automatic operation based on water level and flow direction (i.e. open the shutters when the flow in the canal is towards south & close the shutters when the flow direction changes) about 15m3/sec (average) of water can be diverted to the upstream of the TMB for 12hrs in a day.

2. Wetland in Kuttanad has a total extend of nearly 55000ha, out of which punja cultivation (December – March) is around 38700ha. This means that nearly 16300 ha (55000-38700) is left out without paddy cultivation every year in rotation. This 16300ha can be utilized for storing fresh water and then released in to the lake by pumping to make up the water level reduction due to crop evapotranspiration & lake evaporation.

Water required to be diverted is to supplement the crop evapotranspiration loss from the Lake during the closure period of the barrier i.e. during December 15th to March 15th.

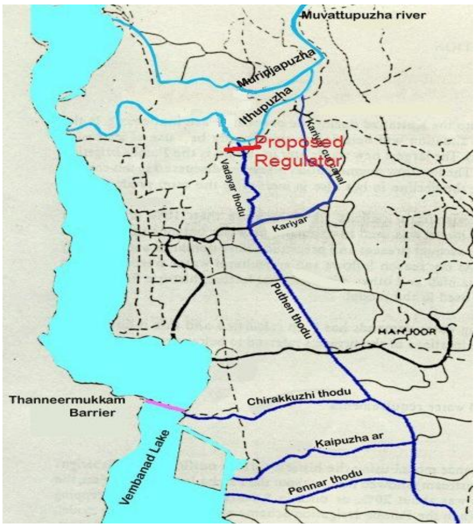

Fig.1. Vembanad Lake and associated River system

IV. Data Collection and Field Study

The cross section of the river was taken at two different points below the Vadayar New bridge(Fig. 2) and Vadayar Old bridge.(Fig. 3) corresponding to known water levels. The cross section obtained was plotted in Autodesk AutoCAD 2011. The area corresponding to other water levels could be easily obtained from the Cad drawing. Also the velocity of flow was taken during known water levels with respect to the Mean Sea Level. The Velocity v/s Water level graph (Fig. 4) was plotted and was interpolated for finding velocity corresponding to other water levels.

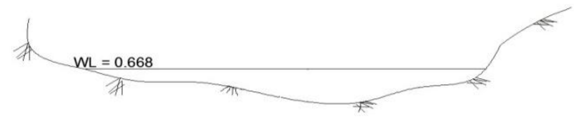

Fig. 2 – Cross section below New Vadayar bridge

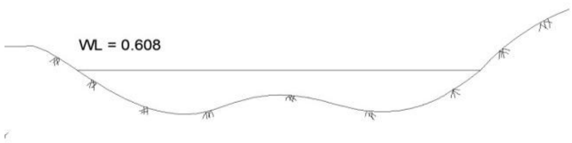

Fig.3 – Cross section below Old Vadyar bridge

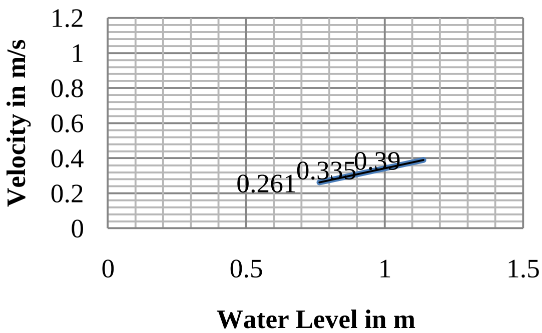

Fig.4 – Velocity v/s Water level Graph

A gauge was established at the proposed location of the Regulator in Vadayar Thodu (350m south of confluence with the Ithipuzha) and the daily maximum and minimum water level occurring in the river was recorded during the closure period of Thanneermukkam Bund i.e. from 15th December 2013 to 15th March 2014. The obtained data is tabulated in Table 1.

TABLE 1. Water Level Data

Date	Maximum Water Level above MSL (m)	Minimum Water Level above MSL (m)
21-12-2013	0.77	0.28
22-12-2013	0.68	0.23
23-12-2013	0.79	0.31
24-12-2013	0.79	0.34
25-12-2013	0.78	0.29
26-12-2013	0.79	0.25
27-12-2013	0.68	0.31
28-12-2013	0.68	0.21
29-12-2013	0.79	0.36
30-12-2013	0.68	0.38
31-12-2013	0.68	0.25
01-01-2014	0.79	0.34
02-01-2014	0.68	0.4
03-01-2014	0.68	0.38
04-01-2014	0.68	0.32
05-01-2014	0.68	0.36
06-01-2014	0.46	0.22
07-01-2014	0.46	0.22
08-01-2014	0.45	0.23
09-01-2014	0.45	0.31
10-01-2014	0.46	0.28
11-01-2014	0.46	0.3
12-01-2014	0.47	0.23
13-01-2014	0.68	0.37
14-01-2014	0.68	0.39
15-01-2014	0.79	0.41
16-01-2014	*	*
17-01-2014	*	*
18-01-2014	*	*
19-01-2014	*	*
20-01-2014	*	*
21-01-2014	*	*
22-01-2014	*	*
23-01-2014	0.97	0.53
24-01-2014	0.98	0.46
25-01-2014	0.98	0.48
26-01-2014	0.96	0.51
27-01-2014	0.95	0.43
28-01-2014	*	*
29-01-2014	*	*
30-01-2014	*	*
31-01-2014	0.88	0.41
01-02-2014	0.96	0.56
02-02-2014	0.97	0.52
03-02-2014	0.98	0.51
04-02-2014	0.99	0.48
05-02-2014	1	0.49
06-02-2014	0.99	0.51
07-02-2014	1	0.47
08-02-2014	0.99	0.49
09-02-2014	0.98	0.52
10-02-2014	*	*
11-02-2014	*	*
12-02-2014	*	*
13-02-2014	*	*
14-02-2014	*	*
15-02-2014	*	*
16-02-2014	*	*
17-02-2014	*	*
18-02-2014	0.97	0.47
19-02-2014	0.96	0.5
20-02-2014	0.95	0.49
21-02-2014	0.96	0.51
22-02-2014	0.97	0.49
23-02-2014	0.97	0.54
24-02-2014	0.97	0.52
25-02-2014	0.98	0.52
26-02-2014	*	*
27-02-2014	*	*
28-02-2014	1.05	0.61
01-03-2014	1.05	0.59
02-03-2014	1.05	0.55
03-03-2014	1.03	0.58
04-03-2014	1.08	0.54
05-03-2014	1.05	0.55
06-03-2014	0.95	0.58

07-03-2014	1.04	0.555
08-03-2014	0.89	0.55
09-03-2014	*	*
10-03-2014	*	*
11-03-2014	*	*
12-03-2014	*	*
13-03-2014	*	*
14-03-2014	*	*
15-03-2014	*	*

In order to find that the proposed channel (Vadayar River) is free from high salinity during the summer, different samples were collected and tested and the obtained data is tabulated in Table 2.

TABLE 2 Salinity Level in Vadayar Thodu

Date	Salinity (ppt)
10-01-2014	0.08
15-02-2014	0.17
08-03-2014	0.203

V. Calculations

5.1 Estimation of Water Required

The amount of water that needs to be augmented is calculated from the 5 year water level data obtained from the gauge established at Thanneermukkam bund on the north (Cochin) and south (Kuttanad) side (Table 3). The area of the Vembanad Lake south of TMB is multiplied with the maximum water level depletion on the south of barrage during the closure period. The area was found from the Cad drawing of Kuttanad obtained from NATPAC.

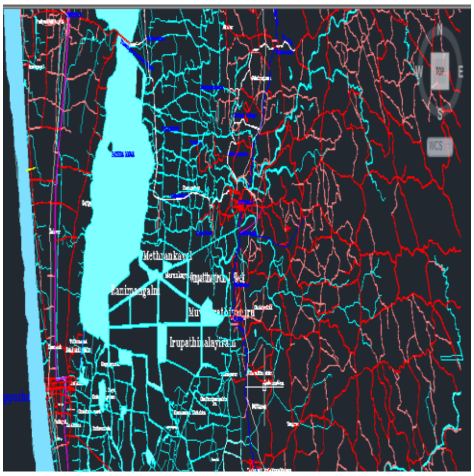

Fig.5 Kuttanad Region

Maximum reduction in water level is found to be 38cm. The total area of Vembanad Lake south of TMB was obtained as $103.51 \times 10^6 m^2$. Hence a total volume of $39.33 \times 10^6 m^3$ ($103.51 \times 10^6 m^2$ x .38m) water needs to be augmented.

Table 3. Thanneermukkam Bund and Water level

Date	Maximum Water level in cm	Water Level when bund is closed	Bund Closed Date	Bund Opened date	Minimum water level in corresponding year (cm)	Difference in water level
19-12-07	64	34	15-12-07	07-04-08	17	17
21-12-08	64	44	23-12-08	31-03-09	12	32
26-12-09	71	48	21-12-09	26-03-10	10	38
30-12-10	68	39	03-01-11	24-04-11	11	28
19-12-11	58	39	21-12-11	26-04-12	15	19
24-12-12	61	41	24-12-12	01-04-13	12	20
07-12-13	61	40	03-01-14			

5.2 Estimation of water regulated

The amount of water that can be diverted to Kuttanad during the closure period of Thanneermukkam bund is calculated from the observed maximum and minimum water level and velocity measured. The water that can be augmented during each fortnight is calculated separately by taking the average of the water levels. The area corresponding to the average water level is taken from the cad drawing and the average of the cross section under the new bridge and old bridge is taken as the average cross sectional area of the river. The velocity is also calculated from the velocity versus water level graph. The obtained velocity was multiplied with a factor of 0.64 to accommodate for the variation in velocity due to horizontal and vertical effect. To calculate the average discharge, minimum discharge was taken as zero since the minimum velocity is zero. Hence average velocity was calculated as the half of maximum discharge.

Quantification of the total volume of water flowing to south during each fortnight is calculated on the basis that 6hours of flow occurs towards south during high tidal period and this phenomenon is observed twice a day. The obtained result is tabulated in Table 4.

VI. Design of Regulator

A Regulator is proposed across Vadayar thodu about 350m south of the confluence with the Ithipuzha River. The operation of the regulator shutter is proposed in such a way that it allows flow towards south during the high tide and block flow towards north during the low tide.

Table 4. Estimated water that can be Regulated

Date	**Discharge in Mm^3**
15th Dec – 31st Dec 2013	7.342
1st Jan – 15th Jan 2014	6.494
16th Jan – 31st Jan 2014	7.049
1st Feb – 15th Feb 2014	7.197
15th Feb – 28th Feb 2014	3.621
1st Mar - 15th Mar 2014	5.184

The designed regulator had 4 bays each with a clear way of 8.5m so that total clearway was 34m and was provided with 4 piers each of 1.5m width. Cutoff sheet piles of 1.5m was provided both on the upstream and the downstream side. Also an impervious floor of 0.6m thickness and 14m length was provided. The longitudinal cross section of the designed regulator is shown in Fig. 6

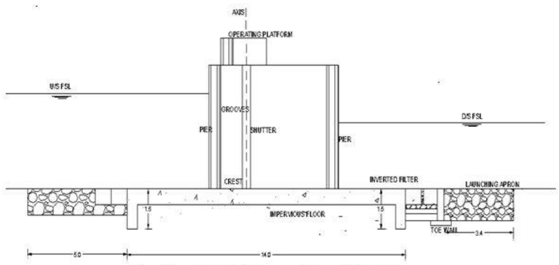

Fig. 6 Longitudinal cross section of Regulator

VII. Result and Discussion

The total volume of water to be augmented to Kuttanad during summer season is found to be 39.33Mm^3. The quantity of water that can be diverted to Kuttanad through the proposed regulator at Vadayar is found to be 36.90Mm^3 i.e about 94% and to supplement the remaining 6% any one of the following methods may be adopted. (i) By storage in pazhnilam. The uncultivated fields may be filled with water before closing of the Thanneermukkam Bund and may be pumped out into the Lake during summer season to compensate for evapotranspiration loss occurring in the Vembanad Lake portion lying in the southern side of TMB. Rani Chitira field is not cultivated for the past many years and its area comes around 5x10^6 m^2. By adopting 2m depth storage of water in these fields a total of 10Mm^3 (5x10^6 m^2 x 2m) can be supplied. (ii)Another possible suggestion is make change in the conventional system adopted for closing the TMB. Present procedure is such that the bund is closed when the salinity level of water is exceeds 2ppt. Instead of this the bund may be closed when the water level is maximum during December in order to ensure that maximum amount of water is available in the Kuttanad region during closure period. This will in turn ensure that sufficient amount of water is available to South side.

From the salinity test it was found that the Vadayar River had salinity level below 2ppt during the closure period of Thanneermukkam Bund and hence it is safe to supply it to the Kuttanad Region.

I. Conclusion

An effective solution to tackle the problems in Kuttanad caused by the ill effects of Thanneermukkam Bund is possible by small interventions in the hydrologic system of the region. When desired amount of fresh water is augmented to Kuttanad the salinity level can be kept below 2ppt and this will help the farmers in increasing their *puncha* (summer) cultivation. Also the decreased salinity level and pollution level due to dilution effect will ensure that people can depend on lake water for their domestic needs even in summer season. The augmented water will provide adequate navigable depth of water even during worst summer situations and is a method for revival of back water tourism in summer. Also a small portion of the Thanneermukkam Salt water barrier can be kept open throughout the year and thereby facilitate migration of fish to the southern part of TMB and improve the fish and aquatic environment in lagoon.

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