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Estimation and Canal Conveyance Losses in Pune District

Rishianand Choudhary[1], Kanak Bafna[2], Manish Pandit[3], Karan Chaudhari[4], Dr. Arpan Deshmukh[5]
[1, 2, 3, 4]*Student, G.H Raisoni College of Engineering, Pune*
[5]*Assistant Professor, G.H Raisoni College of Engineering, Pune*

Abstract: Water is a very precious natural resource. When this precious resource moves through the canals certain part of the water is lost by seepage, evaporation etc. This loss is known as conveyance loss. In present paper, study of Nira Left Bank Canal (NLBC) is done which is situated in Pune district. Total length of canal is 162 Km out of which 30 Km is our study area. Discharge calculations at the head of canal and at 30th Km is done, two standing wave flumes are present at these two locations. Since last few decades, the extensive underutilization has been found in canal irrigation. This issue constitutes the serious lacuna in irrigational planning which often depicts the major problem about optimal water use. As per FAO Aquastat 2015 records for India, out of 91% of water utilized for agriculture purpose, 45% is getting lost under different types of conveyance losses from dam headworks till farms. The conveyance losses constitute the seepage and evaporation losses. Out of these, seepage is a quite significant loss in most of the water conveyance systems. Estimating conveyance losses using physical methods is quite difficult and involves lots of field work and calculations, whereas empirical and analytical methods will not accommodate site condition of respective study area. This study attempted to assess the conveyance loss of Nira Left Bank Bank Main canal with the help of a hydraulic model built on a spatial platform and verified with flow-monitoring events. The hydrospatial model was simulated to understand the canal behaviour and evaluate the conveyance losses. The results show Nira Left Bank Main canal has average 39.96% water conveyance loss.

Keywords: Nira Left Bank Canal; Conveyance Loss; Standing Wave Flumes; hydrospatial model

I. INTRODUCTION

Global agricultural production is heavily dependent on irrigation; however, it has been seen that efficiencies of irrigation systems are often amazingly low. Regional patterns in beneficial irrigation efficiency are found, which are an indicator showing water consumption in crop productivity; due to differences in these features, South Asia and sub-Saharan Africa have the lowest value (less than 30%), while Europe and North America have the highest values (greater than 60%). Present irrigation efficiencies are mostly seen below 50%, as diverted water is considerably lost in the conveyance system or through inefficient farm applications.

India is one of the small numbers of countries in the world provided with plenty of land and water resources. The estimated average rainfall is more than 4000 km3, which is distributed spatially over 329 mha and helps cultivation in 165.3 mha [2]. The southwest monsoon controls the Indian climate and mostly receives its water. Approximately 60 percent of Indian arable land is dependent on rain , and it becomes reason of low productivity, low income, and low employment with high rate of poverty . As per FAO Aquastat 2015 [5], in India, approximately 91% of available water is utilized for agriculture purpose, which is quite high compared to municipal and industrial sectors, out of which approximately 45% of water is lost during its conveyance from the head of canal till it reaches the agriculture fields. According to the Indian Standard, the water loss from unlined canals in India varies from 0.3 to 7.9 m3/s per 106 of wetted surface and about 6,000,000 ha of additional area could be irrigated if this loss gets prevented. Canal irrigation is a major conveyance system for delivering water for agriculture in the alluvial plains of India; however, the conveyance loss from irrigation canals constitutes a substantial percentage of the usable water. However, seepage from canal cannot be controlled completely. A well-maintained canal with a 99% perfect lining minimizes about 30–40% of water seepage loss. Currently, various irrigation projects are struggling with water loss during its conveyance due to seepage losses, evaporation, percolation of water, cracks, and other damages in lined as well as earthen canals. Out of these losses, seepage loss is quite significant in most of the water conveyance systems. The evaporation loss in irrigation networks is generally not taken into consideration because it is only 0.3% of total stream loss, whereas major portion of 98.37% is due to seepage. It is one of the major problems for Ministry of Irrigation and Water Resources that about 80% of the water conveyance system length is passing through the silt and clay soil. It affects water surface profiles, slope, discharge, and water level.

The research carried out by Sultan et al. [9] focused on conveyance losses in irrigation systems in the developing countries as these are the main systems to supply water for irrigation. The research was mainly focused on conveyance losses evaluation in the lined and unlined tertiary channel irrigation supply system in South Asia (Pakistan/India). As per the results, in Pakistan, almost 43.5% of the water losses occurs in lined watercourses and 66% losses in unlined watercourses, and in India, 11% of water losses occurs in lined watercourses and 20–25% in unlined watercourses.

The water conveyance losses from canals need to be curtailed for better performance and efficient water utilization, and accurate estimation is quite important to propose solutions and prioritize the maintenance activities. The water loss estimation from large canals is quite difficult using physical methods like ponding method and involves lots of field work and calculations, whereas empirical and analytical methods will not accommodate site condition of the respective study area. The simulation of water flow in irrigation canals may divulge the management deficiencies and support managers to find solutions to overcome those. These models can be used as suitable tools by incorporating all levels of canal distribution network with their dynamic parameters and model-control structures like gates, orifices, and other hydraulic parameters.

The Geographic Information System (GIS) is base for hydrospatial modelling because of its abilities and effective functionalities to store, retrieve, analyse, manipulate, and display large volumes of spatial digital data and to create maps. It accommodates all the geometric and hydrodynamic data like base width, top width, side slope, full supply depth, cross-sectional area, design discharge, etc., in the hydraulic model. The model verification with the help of a set of measured data should efficiently be used to simulate the existing canal conditions. This helps to understand the canal management shortcomings which impact the canal performance and further possible improvements.

Hydrospatial modelling based on the Geographical Information System (GIS) is used to carry out basic analytical processes for a given set of spatial features. The hydrospatial modelling is to be able to study and simulate spatial objects or events that occur in the real world and facilitate performance assessment using key performance indicators.

This formulates criteria-based alternatives, comparing the data, evaluation models, analysis, and results in a user-specified format. Hydraulic models built with hydrodynamic data offer limitless opportunities for performance improvement of the irrigation systems through simulating and observing the flow in a large and complex canal distribution network using different design and management scenarios.

A. Study Area

As Nira Left Bank Canal off takes from Veer 27 km below Bhatghar Dam district Pune. It is situated in Krishna Basin – Nira Valley. Maximum annual rainfall on dam site is 1998 mm and mean annual rainfall is 953 mm. total length of canal is 162 km. net CCA under this canal is 60,656 ha out of which 27,328 is irrigable area. Out of 162 km length we are focusing on first 30 km length.

B. Objective

The general objective of the study is to point out the different types of water losses occurring in canals and to help the measures which may undertake to increase the water efficiency in canals for irrigation purposes. Along with there is a purpose to highlight the water losses occurring in canals which causes a scarcity to provide efficient water supply to irrigators especially at tale of the canal. It is often observed that mostly the fields at the tale of canals not receive proper supply of water which severely affects the crop production in such areas. It would help to make necessary measurements to minimize water losses in canals in a better way.

II. RESEARCH SIGNIFICANCE

Irrigation in Nira Valley started a century ago. In year 1889, pick up weir at Veer on Nira River constructed and Nira Left Bank Canal off-taking from that weir at Veer. Canal capacity in first stage was 12.88 cumecs. In second stage canal was enlarged in 1926 to carry a designed discharge 20.39 cumecs.

Another addition ti this project was made during the period 1954 to 1962 by constructing a storage dam at Veer but at that time remoulding of Nira Left Bank Canal does not takes place. It is now universally agreed that modernisation of old irrigation system gives better returns on investment as compared to construction of new schemes. Generally modernisation is taken up after about 20 years. The Nira Left Bank Canal is now 100 years old and 60 years have elapsed after it was enlarged last. Therefore, it should get a high priority in modernisation.

III. REVIEW OF LITERATURE

A. K. D. Uchdadiya1, Dr. J. N. Patel

In this paper study includes, The reduction or eliminate of seepage losses in irrigation canals by means of linings assures better utilization of the conveyed water and an improved economic situation, seepage losses from earthen irrigation channels depend on a number of factors. The exact analysis of seepage loss from the canals is quite complex. Theoretical, laboratory and fieldwork has confirmed that seepage rates from canals are affected by the following Factors: Depth of water in the canal, Age of canal, permeability of soil etc.

B. Pradeep Sahu1, A. K.Saxena, Dr. M. K.Travadi

In this paper study includes, Canal linings are expensive. In usual terrain a lined canal may cost twice as much as an equivalent unlined earth canal. This paper discuss In addition to a possible saving in construction costs, the more common benefits derived from canal lining are : Reduced damage to lowlands from seepage or reduced drainage cost, saving in water, Greater safety and Reduced operation and Maintenance costs. Cost analysis of the topic Cement concrete lining more cost effective then other types of lining methods. In Indian scenario and resultant of the study shows that we can save and evolve new methodology of lining (Concrete & tile) So that we can reduce estimating cost of lining project on urban & rural level lining .

C. Bikram Saha

This paper discusses the main causes responsible for water losses which are high density of vegetation, sediment deposition, siltation problem, leakage, lack of maintenance, sharp curves. Water losses comprises of both evaporation and seepage loss. The evaporation loss is the function of temperature, humidity and wind velocity. Practically, evaporation loss can't be controlled but seepage loss can be controlled by providing impervious medium such as brick, concrete, asphalt, geosynthetic material etc between porous soil and water flowing in the system. Concrete used in lining is durable but cost of applying it is very high whereas, geo-synthetic material used is easy to apply and less costly but some protective covering required to resist weathering action and other physical and environmental impacts. In study it has seen that the aging of the thermoplastic polymers has been considered to occur in three distinct zones. Antioxidants present in the resin prevent polymer degradation. Thus, the polymer containing more antioxidant will have more service life. Out of HDPE, LLDPE, PVC, CSPE, EPDM resin. HDPE is the material which lifetime is more. Material recommendation for canal lining depends on locally available material, budget, most importantly soil characteristics to infiltration

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IV. METHODOLOGY

In this paper study includes, study of 30 km stretch of Nira Left Bank Canal, as it is now 100 years old. So that we can know material used for construction of bank work. Depending on material used for construction of bank we can comment on quality of material. Calculation of discharge at head of canal and at 30 km is done with standing wave flume, daily and its average for each month is calculated. From this reading we can calculate % loss in discharge. To minimize this discharge Cement Concrete Lining is suggested. For design of lined canal IS 10430: 30 is referred. Parameters for design of lined canal are Side Slope, Free Board, Berm, Bank Top Width, Dowel 'Dwarf Bund ', Roadway and Drainage, Typical Cross Section, Cross- Section, Discharge and Velocity. Water which is saved due to lining can be given to more irrigable area which will increase intensity of irrigation.

The water losses in canals has signicant diverse effect on the efficient water supply to elds as it is a basic element of irrigation system so there is a need to be aware of these water losses and take necessary precautions to overcome these losses. According to the rules Maharashtra irrigation department 10% of extra discharge is added in design discharge to compensate these water losses. Also annual de-silting works are conducted to keep canal in its best operational condition and to decrease water losses. It is a forecast that Maharashtra may face a severe water deficiency conditions in near future and also presently some of its area are facing this water scarcity situation. The purpose of this case is to provide awareness about the water which is being lost in our irrigation channels because it has become essential to overcome these losses to have anecient irrigation system. In this chapter, study area, data set and methodology used for water losses estimation in irrigation canals will be discussed.

A. Mathematical Model

Inflow-outflow method is adopted to find the amount of water losses in total dis- charge from inlet to outlet and the factors responsible these water losses are considered as seepage losses, evaporation losses, leakage losses, over topping and canal erosion. Current meter is used for the determination of water losses in discharge. The inflow-outflow technique offers direct measurement of water losses with disturbing the operation functions of the canal. This technique is based on determining the proportions of water flowing in and out from a nominated section of canal. The alteration in discharge between inflow-outflow is recognized as water losses. The inflow-outflow technique is a useful approach and it performs well under undulating situations of flow. Further, nonstop measurements can be executed without any inter looping in the system process. Correctness in the results depends on accurateness of inflow and outflow measurements. Inflow-outflow technique gives the loss occurring throughout water passage in the open canals without hindering the regular irrigation process of the certain canal, at the similar time allow precise calculations. Table 3.1 describes different parameters of the canal involving it length, sloe and maximum design discharge.

Sr. Number	Parameters	Description
1	Type	Unlined
2	Length	131233ft
3	Canal Bed Width	100ft
4	Full Supply Depth	6.80 ft
5	Slope	0.11%
6	Design Discharge (cusecs)	1866 Cusecs
7	Maximum Observed Discharge	1729 Cusecs
8	No of No Distributaries	5
9	No of Outlets	45

Table1.1 Basic Parameters of Mula Mutha River canal

The canal selected for study is an unlined canal having no provisions (bricks, concrete work etc.) on it cross section. The Inflow-Out flow method overcome a widespread variety of losses and is assumed to be the most superior method for determining the losses in the Canals. Table 3.2 predicts the assessment of diverse factors disturbing losses in several approaches. It reveals that inflow-outflow technique is the solitary method that computes for all the factors involved in water losses. Others methods mainly discourse just seepage, excluding ponding method which also considers evaporation losses.

Discharges at the start and end of section of the canal were determined agreeing to the velocity-area flow measurement method. The cross-section of the canal at the data collecting points was first distributed into sub-sections, and velocities were checked for both sub-sections according to the two-point method. Discharge velocity at the data collecting points was measured in relative to the revolutions of an Ott-type current meter completing duration of 60 seconds. Discharge velocity was measured by using the succeeding equation:

$$V = 0.2451\, n + 0.014$$

Factor Affect- ing Losses	Tracer Method	Ponding Method	Inflow- Out Flow Method	Empirical Method
Seepage	Yes	Yes	Yes	Yes
Evaporation		Yes	Yes	
Spillage			Yes	
Rodent Holes			Yes	
Breaches/Cuts			Yes	
Dead storage			Yes	
Infiltration			Yes	
Operational			Yes	

Table 1.2 Comparison of Losses in Various methods

While following the two-point method, the discharge velocity was calculated at two upright points, 0.2 (20%) and 0.8 (80%) depths, correspondingly, from the topmost of the water superficial. The discharges at these two heights were then averaged to obtain a single value. Velocity should usually be higher at the 0.2 depth, but should not be greater than double of the velocity of the 0.8 depths. In case the velocity at the 0.2 depths was not greater than the 0.8 depths or if it was two times as higher as at 0.8 depths, then a supplementary reading was engaged at the 0.6 depths. This 0.6 depth was average of the 0.8 and 0.2 means. Evaporation loss (E) was measured through evaporation pan. Moreover, the precipitation was not consider due to limitations that no flow was considered into the segment from outside (I), or distracted from the segment (D), both values were assumed zero. Evaporation pans are installed, a cylinder with a diameter of 47.5 in (120.7 cm) that has a depth of 10 in (25 cm). Following mathematical relations are used to measure total water losses, evaporation losses, seepage losses, water losses rate respectively. Determination of total water losses

$$Total\ water\ losses = Qt - Qo - D + I$$

Where:

Qt = Total discharge of water at inlet of section Qo = Discharge at outlet of section
D = Flow diverted along the reach I = Inflow along the reach

$$Evaporation\ losses\ (in\ cusecs) = \frac{Drop\ in\ evaporation\ pan\ in\ inches\ x\ Surface\ area\ in\ feet}{Average\ day\ light\ in\ hours\ x\ 3600\ x\ 12}$$

$$Seepage\ losses(in\ cusecs) = Total\ water\ losses - Evaporation\ losses$$

Water losses rate in cusecs/ftx10^3 $= \frac{Total\ water\ losses\ in\ cusecs\ X\ 1000}{Length\ of\ canal\ section}$

Evaporation is measured on daily basis as the depth of water (in inches) evaporates from the pan at the site to measure the evaporation losses and also rainwater and precipitation are not considered during the data collection. The time duration for determination of evaporation is only considered average day light hours.

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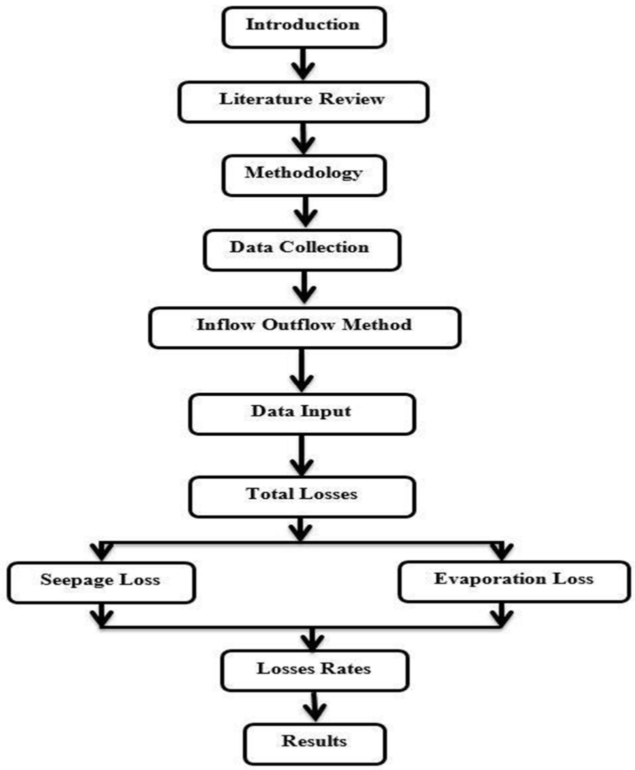
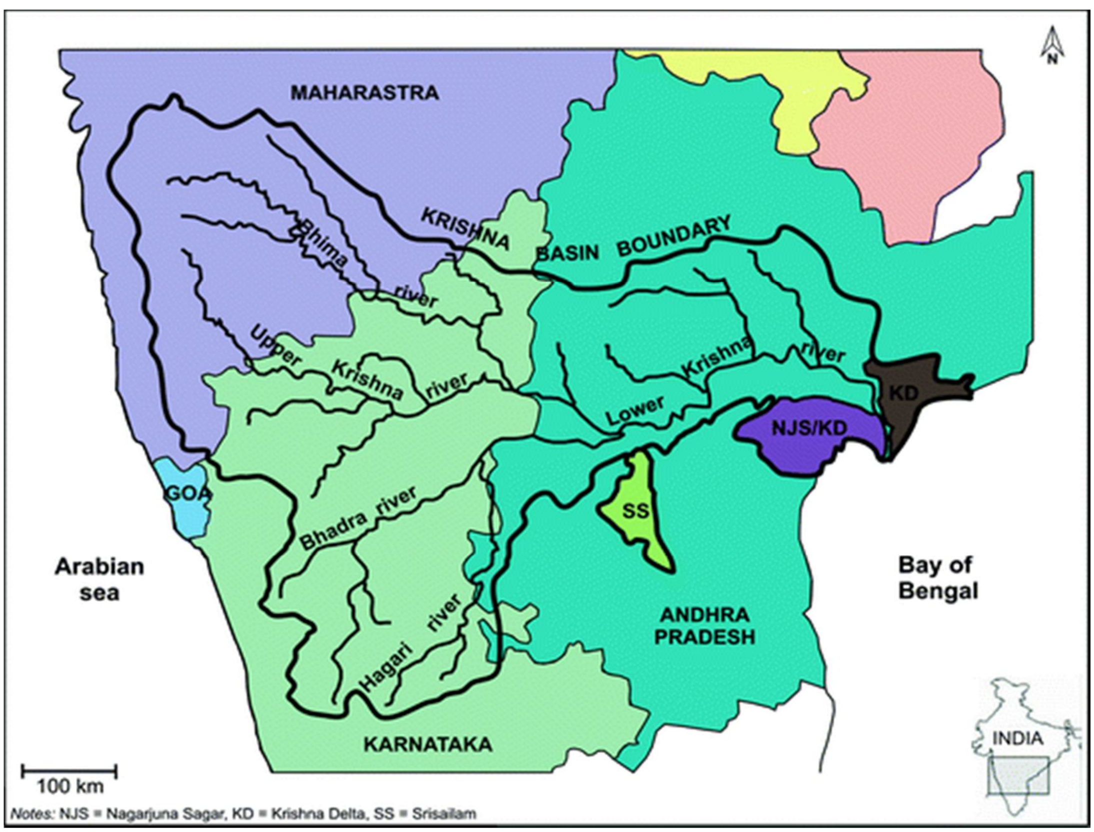


Flow Chart of Study



Location of Krishna Basin – Nira Valley

B. Existing Condition of Nira & Mutha Main Canal

Nira Canal   Mutha Canal

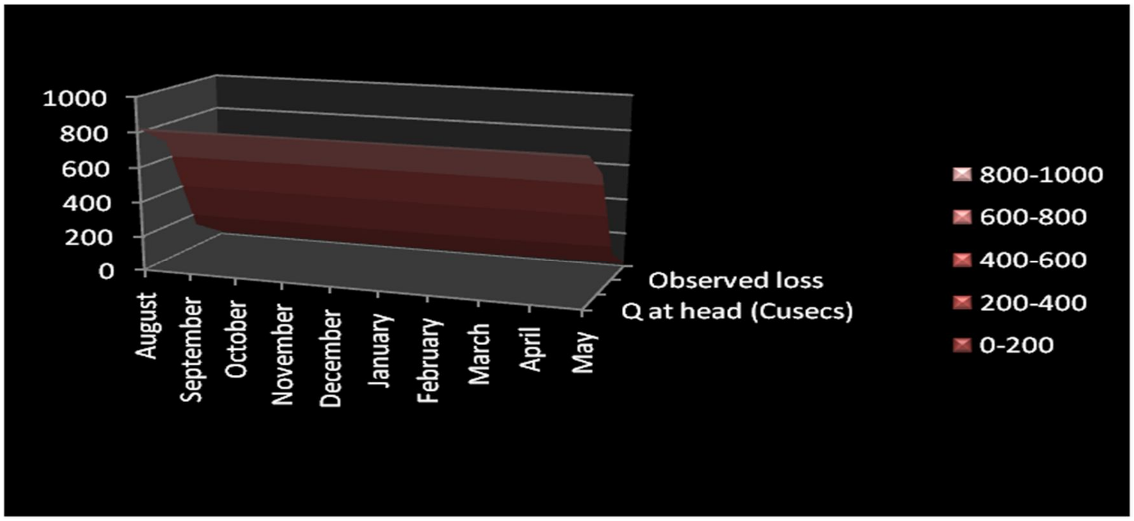
V. RESULTS

The particular study area is deliberated in preceding chapter. In which different methods for determination of losses have also been discussed. Inflow-outflow has been adopted due it suitability of implication for given parameters of understudy canal. Average losses were measured due seepage and evaporation also the percentage losses due to each factor have been determined. Total water losses rates have been determined with respect to net head discharge in section of the channel.

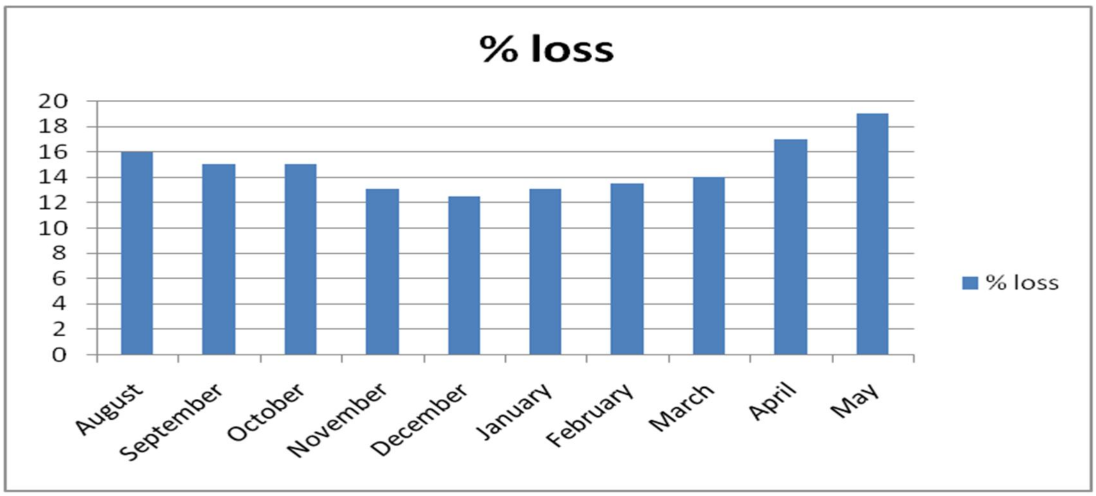
The loss rate was measured through inflow outflow method for canal and given in the table 4.5. The losses are determined in cusecs & percentage losses with respect to total discharge are determined. The readings of discharge between 22-Aug-2018 to 02-May-2019 were measured in period of canal. The readings for discharge are taken at each section with one day interval. Tale 4.1 gives the total water losses in canal at four sections and also percentage losses with respect to head discharge of the canal. It shows the Average water Losses 704.6 cusecs from head to tail of the channel. Also average water Losses percentage with respect to Head Discharge is 14.80%.

Sr. No	Month	Q at head (Cusecs)	Q at 30 km (Cusecs)	Observed loss	% loss
1	August	827	695	132	15.96
2	September	827	703	124	14.99
3	October	827	703	124	14.99
4	November	827	719	108	13.05
5	December	827	724	103	12.45
6	January	827	719	108	13.05
7	February	827	715	112	13.54
8	March	827	711	116	14.02
9	April	827	687	140	16.92
10	May	827	670	157	18.95

Table 1.3 Gives the total water losses in canal and also percentage losses with respect to head discharge of the canal



Graphical Representation Gives the total water losses in canal and also percentage losses with respect to head discharge of the canal



Graphical Representation for percentage Loss

VI. CONCLUSION

The study, conducted for an Mula Mutha canal in district Haveli aims at finding the water losses in unlined canal. Inflow outflow method is applied to determine water losses by splitting the canal in four sections. The difference in inflow and outflow discharge gives the amount of water lost during conveyance process and also indicates the efficiency of the channel. The results of the study highlight the need of safety precautions to avoid water losses and to meet water needs in irrigation sector.

The usual values of water conveyance loss in the study area canal were higher than the provision of extra discharge in design. The surplus in conveyance loss demonstrate that there is no proper restoration work, was accompanied on conveyance canal during land consolidation, maintenance and repair work done are not done by the Maharashtra Irrigation which is the major reason for this increased water loss situation. Furthermore this study may help the Maharashtra Irrigation Department to nominate the critical sections of the canal and to carry rehabilitation work on priority bases.

Losses in canal get control then we can utilise this amount of water to irrigate more area. From reference of project plan, out of net CCA of 60,656 ha. The area to be irrigated is only 27,328 ha. i.e. 45% of available area. If amount of water is saved then intensity of irrigation get increased resulting into increasing in yielding of crop. To control these losses C.C. Lining is suggested which also results in increase in discharge capacity of canal.

VII. BENEFITS OF STUDY

Inflow outflow method is preferably applicable method for evaluating water losses in canals. The study provides a guide for similar studies in study area as there are no proper prior studies about water losses in the relevant study area. The alarming condition of water losses may urge stake-holders to take necessary steps to overcome these losses. Thus, the concerned officials can securely use the results for future water budgeting and planning. The same idea can also be functional in other parts of the country.

VIII. FUTURE RECOMMENDATION

Losses can be mitigated by proper renovation work of the canal and there should be no obstruction in the canal or algae which may decrease the velocity of flow, so that seepage and water losses can be decreased at maximum possible level. The application of suitable technical measures is crucial to decrease water conveyance loss in the network. For this reason, the following actions may be recommended as a start:

Install lining at sections where seepage losses are prominent.

A. Grow proper plants on both sides of canal which may shelter the canal against evaporation losses as the temperature of the region is high for a long portion of yea
B. Some more accurate future technique should be adopted to determine more appropriate results for water losses.

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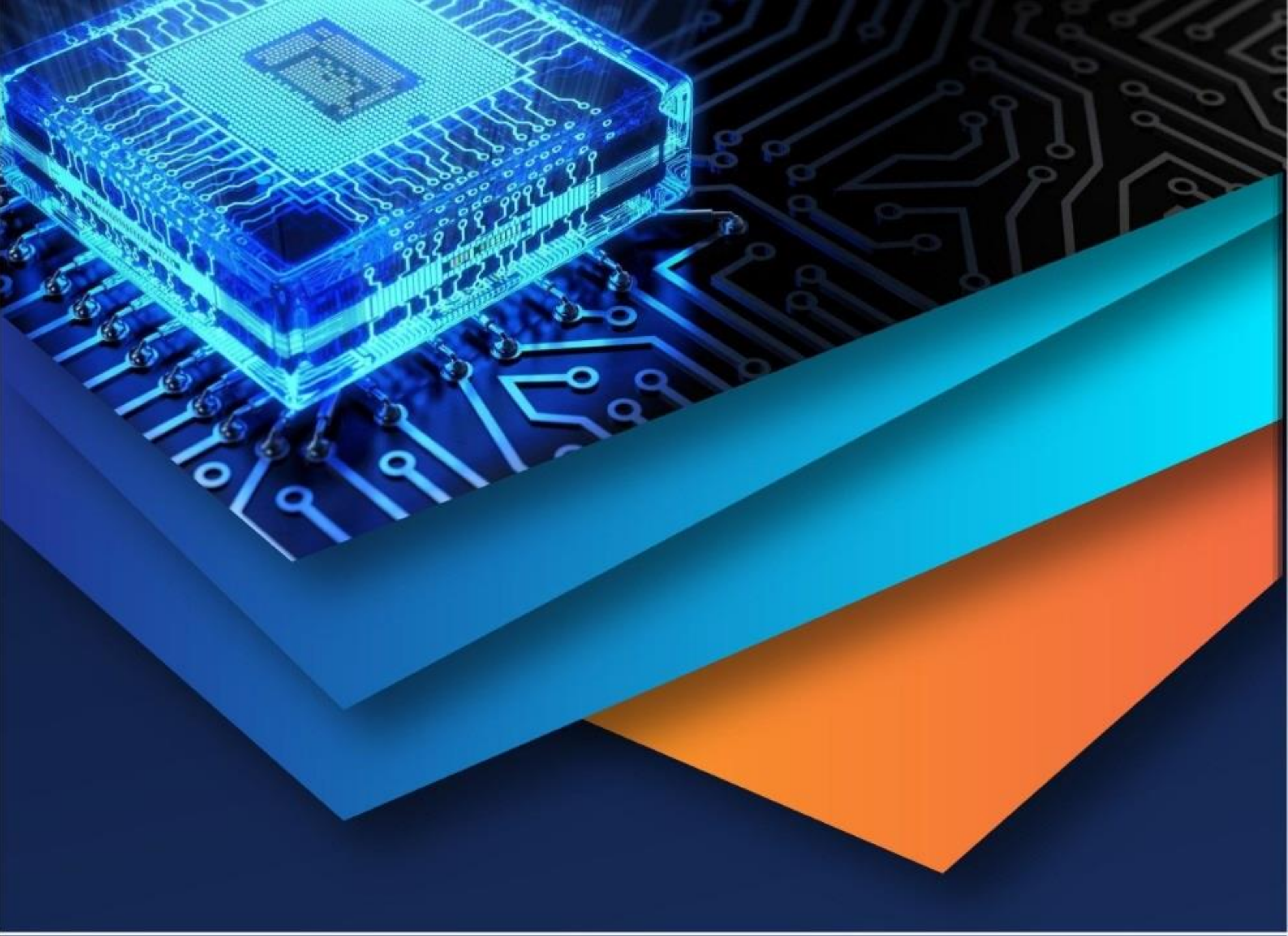

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