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Estimation of Surplus Water for Groundwater Recharging from Ravishankar Sagar Rservoir Basin

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Abstract

This study presents the estimation of excess water from Ravishankar Sagar reservoir basin and its utilization for ground water recharging. The water which overflows through the spillway of a reservoir in monsoon season is considered as surplus water. For this purpose estimation of surplus water (spill water) from reservoir is required. To estimate the surplus water the reservoirs of Mahanadi Reservoir Project (MRP) complex has been operated to fulfill all the demands of the system. An efficient simulation model for operation of reservoirs of MRP complex situated in the state of Chhattisgarh (India) has been developed. Further the surplus (spill) water has been computed. The potential of surplus water indicates the water which can be utilized for ground water recharge at suitable locations.

Keywords: Excess water, Groundwater recharging, Ravishankar Sagar Reservoir, Simulation technique.

INTRODUCTION

During the monsoon season there is high flow in the rivers, hence the reservoirs are filled up to its full capacity during these season. Once the reservoir is full there is overflow through the spillway of the reservoir. This spill water flows down in the river and may cause flooding in downstream. At the same time there may be some areas where there is less rainfall and groundwater storage is also very less. In such situation the spill water from a reservoir can be diverted to such areas for groundwater recharging. For this purpose estimation of surplus water (spill water) from reservoir is required. Ravishankar Sagar Reservoir is one of the reservoirs of the Mahanadi Reservoir Project (MRP) Complex. There are four reservoirs in MRP complex. Water is supplied to the different users through the Ravishankar Sagar reservoir. The spill water from the upstream reservoirs comes to the Ravishankar Sagar reservoir, hence spill from the Ravishankar Sagar reservoir includes the spill of upstream reservoirs. In this paper estimation of excess water from Ravishankar Sagar reservoir has been done. To estimate the excess water, the reservoirs of the system is required to be operated to fulfill all the demands of the system. Yeh (1985) reviewed the state-of-the-art of mathematical models developed for reservoir operations, including simulation. Labadie (2004) presented a review to assess the state-of-the-art in optimization of reservoir system management and operations and consider future directions for additional research and application. Simulation is a technique by which we imitate the behavior of a system. Simulation is a very powerful technique in analyzing most complex water resource system in detail for performance evaluation. For multi-reservoir operation problem simulation technique is used (Vedula and Mujumdar, 2006). The MRP Complex is a multi-reservoir system, hence it has been decided to use simulation technique for operation of the reservoirs of this system. Maass et al. (1962) demonstrated the application of simulation techniques to evaluate the economic performance of a river basin. The earliest simulation model associated with a system of reservoirs appearing in the literature seems to be the study performed by the US Army Corps of Engineers in 1953 for an operational study of six reservoirs on the Missouri River (Hall and Dracup, 1970). A comprehensive study of various simulation models was presented by Wurbs (1993). Models were compared from a general overview perspective, with emphasis on practical application. Sechi and Sulis (2009) illustrated a procedure integrating optimization and simulation models with the aim of identifying and evaluating drought mitigation measures by means of a proactive approach. Reichold et al. (2010) presented a methodology to identify watershed management strategies that will have a minimal impact on the flow regime and downstream ecosystems. This methodology utilizes a simulation-optimization framework. . Rani and Moreira (2010) presented a survey of simulation and optimization modeling approaches used in reservoir systems operation problems.

Simulation software MIKE BASIN (2009) has been used for analysis in this work. MIKE BASIN is a multipurpose river basin simulation package developed by DHI (Danish Hydraulic Institute), Denmark, have extensive reservoir modeling capabilities, and accommodate multi-purpose reservoirs and multiple reservoir system. Ammentorp (2001) applied MIKE BASIN to Nakanbe Catchment to identify suitable strategies for the combined management of this reservoir. Application of MIKE BASIN for water management strategies in a watershed of Mun River Basin located in Northeast Thailand was reported by Jha and Gupta (2003). Nishat and Rahman (2009) demonstrated a modeling effort to set up a water resources management model, MIKE BASIN, over the Ganges, Brahmaputra, and Meghna (GBM) river basins, India.

RAVISHANKAR SAGAR RESERVOIR

Ravishankar Sagar Reservoir is one of the reservoirs of the Mahanadi Reservoir Project (MRP) Complex. Water is supplied to the different users through this reservoir. The

Mahanadi Reservoir Project (MRP) Complex is situated in Dhamtari District of Chhattisgarh state in India. MRP Complex consists of Mahanadi basin and Pairi basin. This project comprises of four reservoirs namely Ravishankar Sagar Reservoir, Murumsilli Reservoir and Dudhawa Reservoir in Mahanadi basin and Sondur Reservoir in Pairi basin. Ravishankar Sagar Reservoir is constructed across Mahanadi river, Dudhawa reservoir is situated on upstream of Ravishankar Sagar Reservoir on Mahanadi river and Murumsilli Reservoir is constructed across Silliyari river a tributary of Mahanadi river on upstream of Ravishankar Sagar Reservoir. Sondur reservoir is situated at the upstream of Dudhawa reservoir and constructed across Sondur river in Pairi basin. Sondur and Dudhawa reservoirs are connected by an interbasin link canal called Sondur Feeder canal. This interbasin link canal transfer water from Sondur reservoir in Pairi basin to Dudhawa reservoir in Mahanadi basin. Sondur feeder canal feed water to Dudhawa reservoir as well as it irrigates some command area. There is no direct irrigation through Dudhawa and Murumsilli reservoirs, they feed water to Ravishankar Sagar reservoir. The MRP Complex is intended to provide irrigation and to meet municipal and industrial demands of Bhilai Steel Plant (BSP) and its township. Thus Mahanadi Reservoir Project Complex is a multipurpose multi-reservoir system. The index map of MRP Complex is shown in Figure 1.

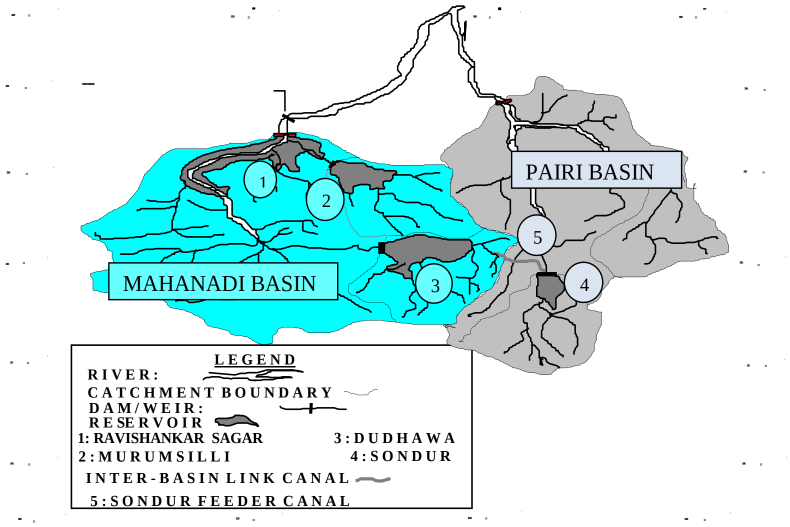

Figure 1. Index Map of Mahanadi Reservoir Project (MRP) complex.

Development of Simulation model for reservoir operation

In MRP complex, Ravishankar Sagar reservoir is connected with two upstream reservoirs Murumsilli and Dudhawa and there is inter basin transfer of water from Sondur reservoir to Dudhawa reservoir. The schematic diagram of MRP complex has been shown in Figure 2. For different need water is supplied through Ravishankar reservoir only, hence Dudhawa and Murumsilli reservoirs are feeder reservoirs. Sondur reservoir feed water to Dudhawa reservoir as well as it irrigates some command area. By observation of the Figure 2, it is clear that there is only one way of supplying water from Sondur to Dudhawa but there are three possible ways of supplying water from Murumsilli and Dudhawa reservoirs to Ravishankar Sagar reservoir. These three ways of supplying water has been simulated in MIKE BASIN software and designated as three models. These three models are:

(i) **Model-I:** In this model Murumsilli reservoir has been given first priority and Dudhawa has been given 2nd priority to feed water to Ravishankar reservoir.

(ii) **Model-II:** In this model Dudhawa reservoir has been given first priority and Murumsilli has been given 2nd priority to feed water to Ravishankar reservoir.

(iii) **Model-III:** In this model Murumsilli and Dudhawa have been given equal priority to feed water to Ravishankar reservoir.

The above three models have been simulated in MIKE BASIN. The efficient model out of the three models will be used for operation of the reservoirs of the system.

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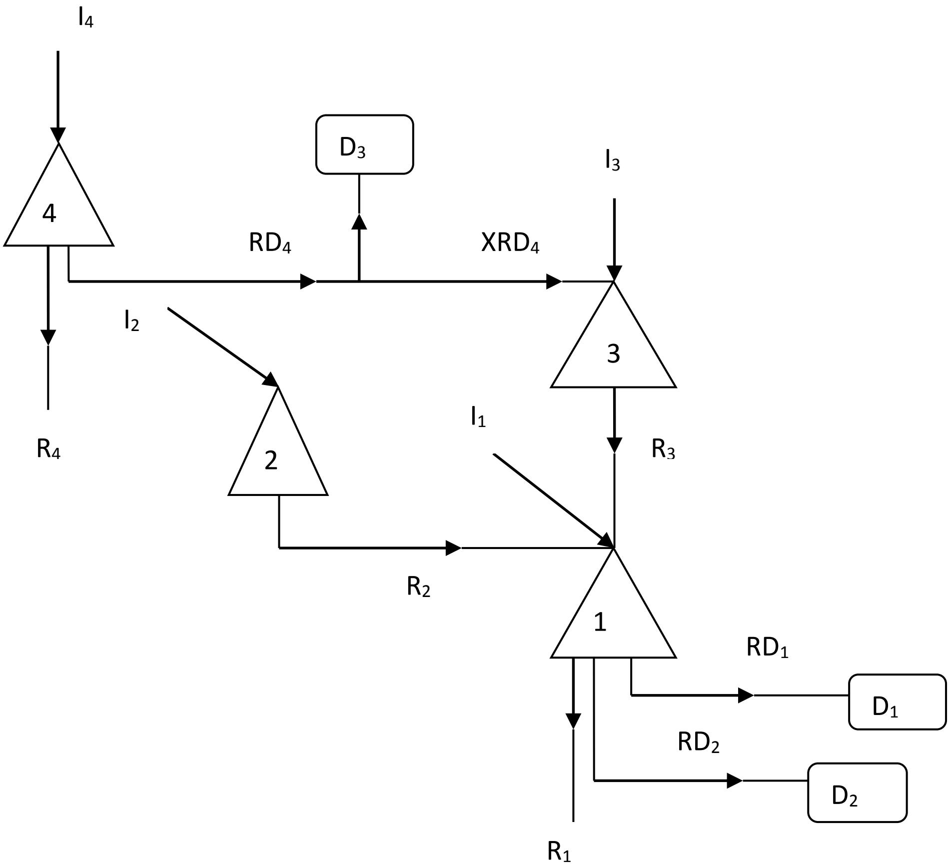

Reservoir	Release in canal	Demand
1. Ravishankar	RD1- Mahanadi feeder canal	D1- Mahanadi feeder canal demand
2. Murumsilli	RD2- Mahanadi main canal	D2- Mahanadi main canal demand
3. Dudhawa	RD4- Sondur feeder canal	D3- Sondur feeder canal demand
4. Sondur	**Release from reservoirs**	
Inflow to reservoir	R1- from Ravishankar	
I1- Ravishankar	R2- from Murumsilli	
I2-Murumsilli	R3- from Dudhawa	
I3-Dudhawa	R4- from Sondur	
I4-Sondur		

Figure 2: Schematic representation of MRP-Complex

RESULTS, ANALYSIS AND DISCUSSION

The three simulation models (Model-I, Model-II, and Model-III) have been used for operation of the reservoirs to satisfy the different demands (Irrigation and M&I demand) of the system. To find the efficient model, the annual deficit between demand and supply for different users has been computed for each model. The model having least value of deficit for a specified duration will be the efficient model. Out of the three models the total deficit was found minimum in Model-I, hence Model-I is the efficient model. The results of Model-I have been compared with the results of earlier reported optimization (PGP) model (Verma et al. 2010). The result of Model-I is very close to the result of optimization (PGP) model hence this model is performing satisfactory. The Model-I has been selected for operation of reservoirs of the MRP Complex due to its satisfactory performance. The spill analysis for Mahanadi Basin has been done for the effective utilization of the spill water of the system. The spill of

Mahanadi Basin is through the Ravishankar Sagar Reservoir. The analysis has been done from 1996 to 2008 and the amount of monthly spill has been computed for this period. The results of monthly spill analysis have been shown in Table 1. The amount of annual spill has been shown in table 2. The average annual spill from Ravishankar Sagar Reservoir is 300.51 Mm^3. Normally the spill occurs in the month of August and September. From table 2 it is clear that out of 13 years spill is for 8 years i.e. spill occurs for 60% of time. There is no spill in the years 1997, 1999, 2001, 2003, 2008 due to less rainfall in these years. This excess water from Ravishankar Sagar Basin can be utilized for ground water recharging in the adjoining areas.

Table 1. Monthly Spill from Ravishankar Sagar Reservoir

Year	Monthly Spill in Mm^3			
	July	August	September	October
1996	0	88.94	103.27	0
1997	0	0	0	0
1998	0	84.86	214.34	0
1999	0	0	0	0
2000			21.36	0
2001	0	0	0	0
2002	0	619.80	100.43	0
2003	0	0	0	0
2004	0	536.72	426.93	171.89
2005	0	184.82	196.77	0
2006	0	123.24	318.14	0
2007	65.81	495.78	153.56	0
2008	0	0	0	0

Table 2. Annual spill from Ravishankar Sagar Reservoir

Year	Annual Spill(Mm3)
1996	192.21
1997	0
1998	299.2
1999	0
2000	21.36
2001	0
2002	720.23
2003	0
2004	1135.54
2005	381.59
2006	441.38
2007	715.15
2008	0
Average Anuual Spill	300.51

CONCLUSION

Monthly spill analysis of Ravishankar Sagar reservoir has been done. From analysis it is observed that normally the spill is in the month of August and September. Spilling occurs for 60% of time. The average annual amount of spill water from Ravishankar Sagar reservoir basin is 300.51 Mm^3. This excess water from Ravishankar Sagar reservoir basin is flowing unutilized. This excess water can be utilized by diverting this water to the adjoining area where there is less rainfall and groundwater storage is also very less. Groundwater storage of such area can be increased by utilizing this excess water for groundwater recharging.

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