WATER BALANCE STUDY OF TANK CUM WELL SYSTEM IN HIGH RAINFALL REGIONS OF EASTERN INDIA

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ABSTRACT

The tank cum open dug well system is a proven technology for providing reliable irrigation to croplands in the plateau region of eastern India. The system comprises of a series of tanks with open dug wells in the recharge zone of the tank that reharvest back the seepage water. Thus, the rainwater remaining in the tank as well as partial seeped water is used for providing round the year full irrigation. This system was initially evaluated in field in Keonjhar district of Odisha of eastern India with six tanks and five wells in two drainage lines. In the current study the water balance components of the tank cum well system has been evaluated. The water balance analysis showed that there is effective seepage into the tank in the standard week no. 28 to 49. The analysis of piezometric water level data showed higher specific subsurface discharge in the region between the tank and the well indicating that the tank is able to recharge to the downstream well. The pumping test analysis in the open well showed that the yield of the open well varies from 8.74 m^3/day in the month of October to 3.72 m^3/day in the month of April.

Key words: Recirculatory aquaculture system, biofilter, silo, rohu, water quality

INTRODUCTION

Irrigation is a catalyst for improving and stabilizing agricultural productivity which in turn alleviates poverty. Hence there is a strong justification for investing in water resource development for small-scale agriculture. Small holder irrigation is generally accepted to include farmers who irrigate areas up to fraction of a hectare to 10 hectares of land (Albinson and Perry, 2002). In high rainfall regions of eastern India, rainwater management has a potential of being an irrigation water resource which can provide full irrigation in conjunction with rainfall. Several researchers have designed small systems for irrigation management and water resource development based on runoff recycling (Palmer *et al*., 1982; Helweg and Sharma, 1983; Verma and Sarma, 1990). But most of them are for supplementary irrigation and hence their impact on total livelihood scenario is not significant enough to bring them out of vicious circle of poverty. Bhatnagar *et al*. (1996), Srivastava (1996) and Srivastava (2001) have shown that reliable irrigation system through runoff recycling can be designed in sub-humid high rainfall areas of India. The technology was further refined and a micro level water resources development system through rainwater management comprising of tanks and wells was developed. This system was initially evaluated in field in Keonjhar district of Odisha of eastern India with six tanks and five wells in two drainage lines. (Srivastava *et al,* 2009).

In this tank cum well system, the tank is constructed to store runoff water. This tank is able to provide irrigation to transplanted rice in kharif and low duty crops in full command or heavy duty rabi crops in partial command. The seepage loss from this tank as well as percolation loss from the paddy fields is reharvested back from an open dug well downstream the pond. This well serves for providing water for nursery and irrigate additional area during kharif, rabi as well as summer. However, there is a need to study the water balance components of the tank cum well system to completely understand the behavior of the system. In order to carry out the study, the experiment was carried out in Directorate of Water Management research farm by constructing a tank cum well system in a 3.2 ha micro-watershed area.

MATERIALS AND METHODS

A 3.2 ha micro-watershed wasteland area was selected in the Directorate of Water Management research farm at Deras, Bhubaneswar. A 2500 m^3 capacity tank was constructed on the drainage line of the micro-watershed. Inlet to the tank was provided by a 165 mm dia PVC pipe and outlet of the tank was provided in terms of a drop spillway. An open dug well of 8 m depth and 6 m outer diameter was constructed at about 70 m downstream of the tank. The irrigation facility in the area was developed by construction of underground pipeline system. Four storage reservoirs were constructed at four different elevated locations of the micro-watershed so that majority of area can be covered by irrigation using them. The storage reservoirs were used for initially storing the water and then irrigating the plants by gravity fed irrigation. The water was pumped from the tank and the well, and stored in the storage reservoir through underground pipeline system.

Twelve hundred acacia mensium plants and 150 eucalyptus plants were planted in the waterlogged portion of the land. Four hundred mango plants, 90 guava plants, 2000 pineapple suckers and 3000 lemongrass slips were also planted in the area. The guava, pineapple, and lemon grass were planted as intercrops to the mango plants. The irrigation was done by flexible PVC pipe drawing water from the storage reservoirs by gravity.

Water balance analysis of the tank

The water balance of the tank was studied using the mass balance equation where difference between inflow and outflow is equal to change in storage. The following equation was used for the study.

$$(I + P) - (E + Q + O + S) = \Delta S \quad \text{... ... .. (1)}$$

Where, I = surface water inflow into the tank, P = precipitation, E = evaporation, Q = pumping of water from the tank for irrigation, O = surface outflow from the tank, S = seepage losses from the tank and ΔS is change of storage in the tank.

The rainfall and evaporation data were available in the meteorological observatory of the research farm. The surface water inlet to the pond through the pipe and the water outlet from the tank through the weir was monitored regularly. Similarly the water withdrawal from the tank for irrigation in different days was recorded. The change in storage in the tank was found out from the water level in the tanks. The seepage loss from the tank was obtained from the water balance equation as all other components were measured and thus were having a known value.

Groundwater monitoring and analysis

In order to monitor the groundwater level, six piezometers were installed in the study area, two in the upstream side of the tank, two between the tank and the well and two in the downstream side of the well. Periodic monitoring of groundwater level was done in six piezometers. In order to estimate the specific subsurface discharge, hydraulic conductivity was measured at upper, middle and lower reaches. The average hydraulic conductivity was 1.68, 1.65 and 1.68 cm/hour in upper, middle and lower reach. The specific subsurface discharge in three sections was calculated using Darcy's law

$$v = K.i \quad \text{........... (2)}$$

Where, v = specific subsurface discharge, K= hydraulic conductivity, i= hydraulic gradient=$\Delta h / \Delta l$.

Pumping tests in open wells

In order to study the monthly variation of well yield, pumping tests were conducted in the open well in different months. After pumping the wells for a sufficient duration, the recuperation of the open well with time was measured. The recuperation rate and cumulative recuperation for each pumping test were analyzed. The well yield in different months were obtained and compared.

RESULTS AND DISCUSSION

Water balance of the tank

The water balance analysis in the year 2008-09 showed that there is an effective seepage into the tank in the monsoon season i.e. from standard week no. 28 to 49 (Fig. 1). It implies that the effects of monsoon existed till the 49^{th} week, upto which the seepage into the tank exceeded the seepage from the tank. From 50^{th} week to 27^{th} week there is a seepage loss from the tank. Maximum effective seepage of 6.17 mm/day into the tank was observed in week no. 45 and maximum effective seepage loss of 6.40 mm/day from the tank was observed in week no. 5. The surface water inlet into the tank started in the week no. 25 at 17 lit/min, reached a maximum of 300 lit/min in week no. 38 and then gradually reduced and became zero from week no. 7 onwards (Figure 2). Generally the surface water inflow into the tank increased with rainfall.

The tank water level along with well water level and rainfall has been plotted and shown in Figure 3. The water level in the tank and well were arrived at considering the reference water level of 25 m of the tank weir. The tank water level varied from a minimum of 24.32 m in week no 24 to a maximum of 25.03 m in week no. 38. The maximum water level in the tank was restricted by a spillway in the form of a weir at the outlet of the tank. The well water level varied from a minimum of 22.18 m in week no. 24 to a maximum of 23.55 m in week no. 38. There was a similarity in trends between the tank water level and well water level and there is an increase in both the water levels in the monsoon season. There was a sudden rise in water level with the start of the rainy season in the week no. 24 to 26. Due to surface water inflow into the tank, there was an immediate rise in water level in the tank in comparison to well.

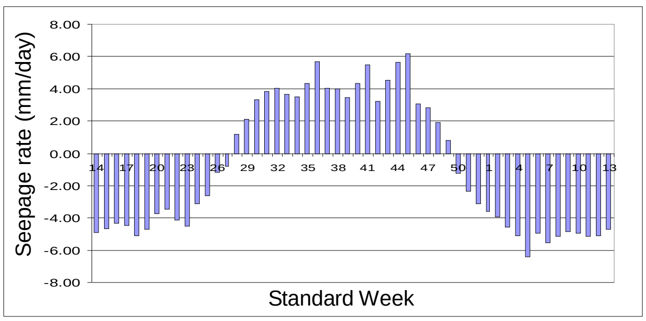

Fig. 1 : Seepage losses from the tank in different standard weeks.

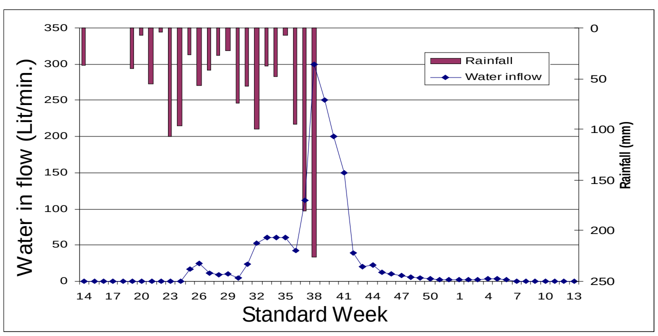

Fig. 2 : Surface water inflow into the pond with rainfall data

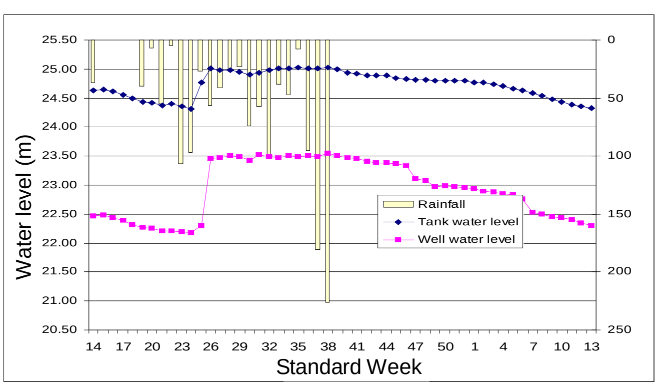

Fig.3 : Water level in the tank and well along with rainfall data

Groundwater level and specific subsurface discharge variation

Figure 4 shows groundwater level in six piezometers in different weeks. Piezometers 1 and 2 lie in the upper reach of the study area, piezometers 3 and 4 lie in the middle reach of the study area and piezometers 5 and 6 lie in the lower reach of the study area. There was lesser variation of groundwater level in the upper reach as this area remains waterlogged due to seepage from upstream dam and canal. As there was a water flow from the upstream side to downstream side, groundwater levels are higher in the upstream side followed by middle reach and lower reach respectively. The groundwater level in piezometer 1 varied from a minimum of 25.51 m to a maximum of 26.14 m, the groundwater level in piezometer 2 varied from a minimum of 25.11 m to a maximum of 25.93 m, the groundwater level of piezometer 3 varied from a minimum of 23.29 m to a maximum of 24.46 m, the groundwater level in piezometer 4 varied from a minimum of 22.75 m to a maximum of 23.80 m, the groundwater level in piezometer 5 varied from a minimum of 21.74 m to a maximum of 23.05 m and the groundwater level in piezometer 6 varies from a minimum of 21.65 m to a maximum of 23.05 m.

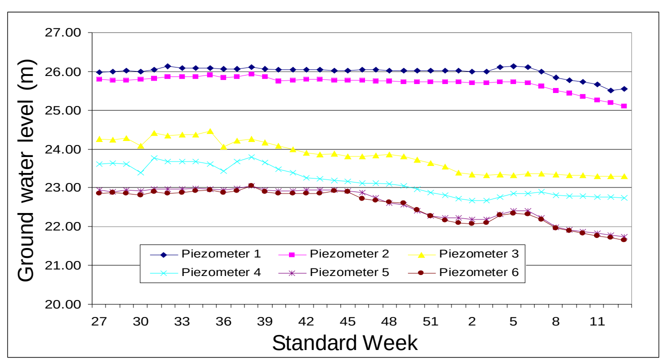

Fig. 4 : Variation of groundwater levels in piezometers

The specific subsurface discharge (v) at three sections in different weeks is shown in Figure 5. The average values of v in upper reach, middle reach and lower reach are 5.82, 10.64 and 1.88 mm/day respectively. The higher specific subsurface discharge in the middle reach indicates that the tank is able to recharge to the downstream well.

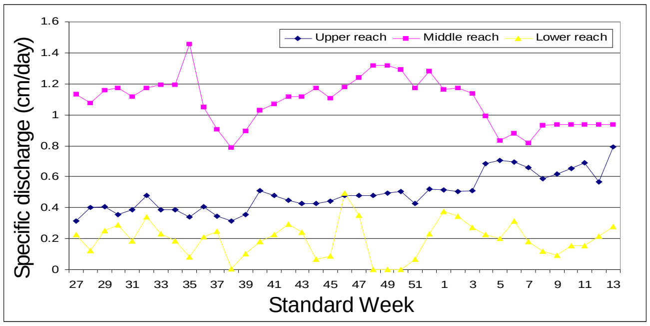

Fig. 5 : Specific subsurface discharge at different sections.

Yield of open well

The variation of yield of the wells in different months is shown in Figure 6. The yield of the open well was 8.74 m^3/day in the month of October. After this it slowly decreased to 5.76 m^3/day in the month of November, 4.7 m^3/day in the month of December, 4.4 m^3/day in the month of January, 4.15 m^3/day in the month of February, 3.92 m^3/day in the month of March and 3.72 m^3/day in the month of April. The yield of the open well has been observed to be on a lower side due to relatively low hydraulic conductivity in the soil profile.

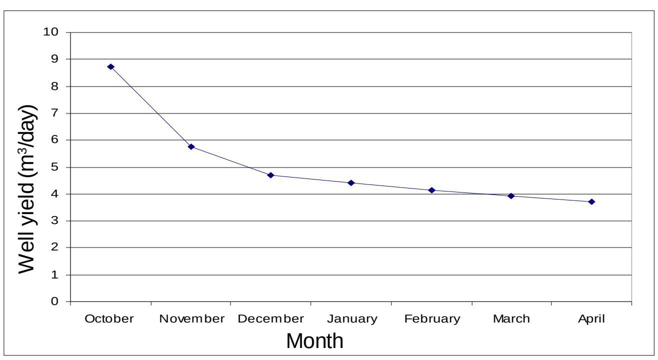

Fig. 6 : Variation of yield of open well in different months

CONCLUSION

The water balance components of the tank system has been analyzed. There is an effective seepage into the tank in the monsoon season i.e. from week no. 28 to 49 and from 50th week to 27th week there is a seepage loss from the tank. The specific subsurface discharge was highest in the region between the tank and the well which indicates that the tank is able to recharge to the downstream well. The pumping tests showed that yield of the open well varies from 8.74 m^3/day in the month of October to 3.72 m^3/day in the month of April.

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