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Agricultural Best Management Practice using SWAT Model

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Abstract- Broad disintegration of soil contributes deterioration of land throughout the world. Eroded soil deposits in different water storage structures, consequently Lessing their ability. It is one of severe crisis in semi arid region where crest rich soil gets eroded by runoff. Water is the mainly significant natural resources whose supervisation is crucial for current and upcoming usage. Thus both sediment and runoff modeling can be done by using hydrological model in an interface with Arc-GIS software. In this study, an attempt was made to evaluate the impact of BMP's on Bennethora watershed, since no soil conservation practices were conducted before. The model was calibrated for five years and validated to six years for monthly discharge and sediment data. BMP's incorporated are filter strips and stone bunds. The simulated result shows that implementation of filter strips and stone bunds scenarios reduce the sediment yield at both watershed and sub watershed levels.

Index Terms- SWAT, sediment yield, filter strips, stone bunds

1. INTRODUCTION

Best management practices are utilized to diminish non-point source of contamination coming about as of different agrarian exercises and enhance water quality [4]. To assess the long term effect of usage of Water Quality Management Plans on nonpoint source contamination at the farm level & watershed level utilizing a SWAT approach [2].The SWAT was utilized to show soil disintegration, distinguish soil disintegration inclined territories & to evaluate the consequence of BMPs to decrease silt yield [3]. The SWAT predicts the outcome of soil conservation measures on water, dregs, and agricultural flow in watersheds with variable soils, land utilize, & executive conditions over time [2].Arid and semi arid-dry districts cover very nearly 40% of universes land surface. Water asset management is more complex than it is in moist zones because of absence of enduring streams and other water resources. Residue stores in North African watershed prompts loss of water stockpiling limit in dams. Forecast of spillover and silt yield is critical for surveying the dirt disintegration threats and deciding reasonable conservation practices [1]. In nations like India, assessment of overflow/dregs yield is basically compelled by the non availability of field data and subsequently, where the adjusted parameters from Khadakohol was utilized to Harsul and its suitability was evaluated in an ungauged setting and the outcomes are observed for estimation of runoff[6]. This problem is generally due to lack of systematic investigation on silt deposition & improper planning of sediment and erosion control measures. This siltation problem is high in inferior Bhima basin that includes Bennethora watershed. Since no study conducted in present study locale to estimate agricultural BMP's using models. Hence this provides an attempt to estimate the benefits of structural and non structural BMP's for this study area. The foremost goal of the study is to assess the agricultural Best management practices such as filter strips, stone bunds to manage the sediment yield by the SWAT hydrological model.

2. STUDY SITE

In south India, Krishna River is the largest river basin. Bhima River itself is a tributary of the Krishna. The Bennethora River originates from Kagina River on whose right bank is in Malkhed. Malkhed, Sedam and Chitapur are of the main towns on the river bank. The catchment area of Bennethora lies amid 17°00'N and 19°00'N and 76°00'E and 78°00'E. Study site is located in the South-eastern part of Gulbarga district, covering catchment of 8291.52km^2. The leading soil features are thick spread of black soil occupied by the laminated sedimentary lime stones of the Bhima series. Black soil lies in lower depth & has high percolation capacity. Soil forms in the study area are sandy loam, clay loam and sandy clay. Land uses in the watershed are agricultural, ranges and wetlands. Climate in this region is dry and healthy and the seasons are on the pattern of those generally found in the Deccan. The summer season begins in center of February and proceeds to the initial days of June. The south west monsoon season takes after from that point and expands upto finish of September, October and

November form the post- rainstorm term. The period from December to center of February is the cold season.

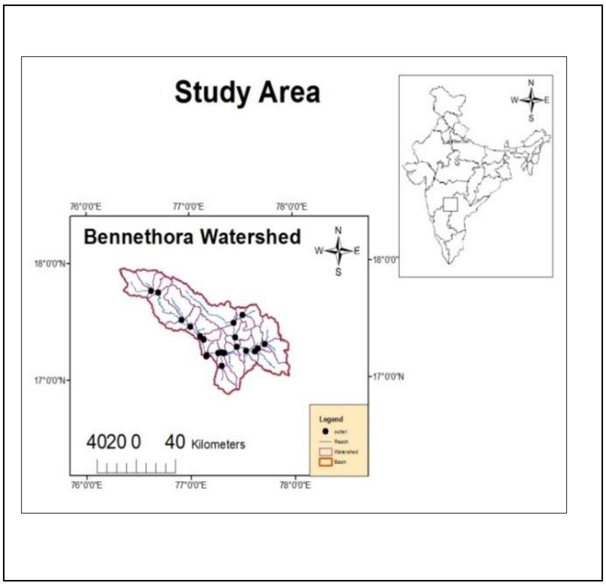

Fig 1. Location of study area

3. METHODOLOGY

Figure 2 shows the flow chart of the present work. Input of projected DEM (coordinated system WGS 1984 UTM zone 43 N), watershed was delineated for the river. Then HRU analysis is carried out using data input. Land use and soil map were collected. The next step is uploading of meteorological data collected for the catchment that uses the data of influencing stations. The model is setup and run for the above mentioned inputs by giving sufficient warm up period. The calibration and validation of the model is done manually. Add BMP's by altering suitable SWAT parameters.

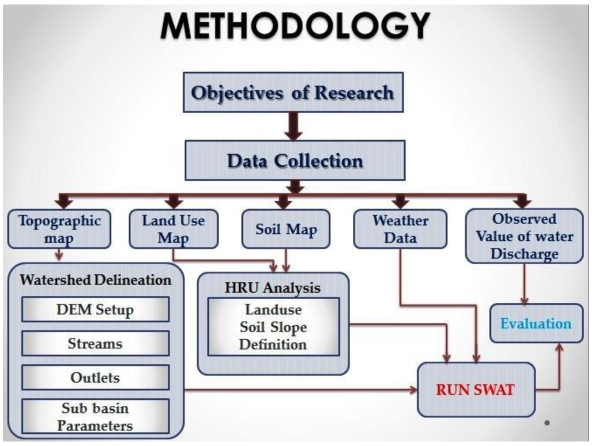

Fig 2. Progress chart for SWAT[5]

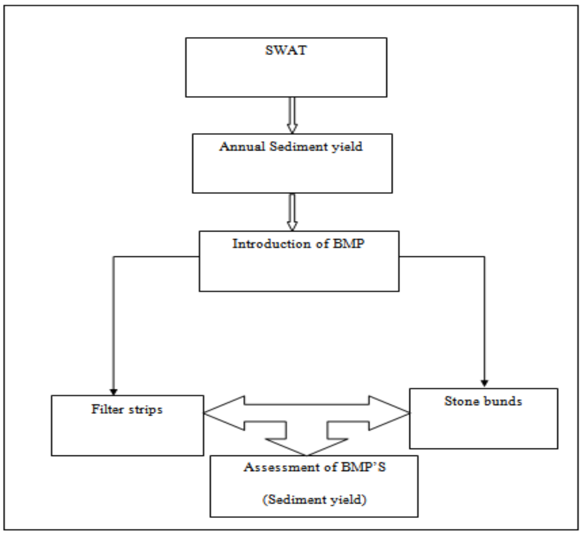

Fig 3. Work flow chart for assessment of BMP scenarios using SWAT tool

3.1. Data required

Following remote sensing data were used in current study: 1) DEM with 30m resolution 2) Soil map 3) Land use map 4) Weather data 5) 0bserved outflow and sediment data from gauge station.

Table 1. Land use land cover and area coverage

Land use classification	**Description**	**Area (%)**
Water body	Area covered by water	20%
Wetland mixed	Area covered by wetlands	58.20%
Range-Brush	Area covered by bushes, range	20.02%
Agricultural-general	Farming land	1.54%

Table 2. Soil types

Soil classification	**Area (%)**
Sandy-loam	38.01%
Clay-loam	0.11%
Sandy-clay	61.88%

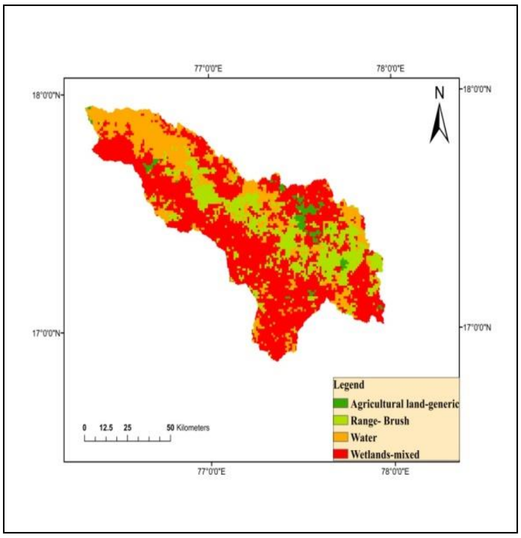

Fig 4 . LULC & soil map of study area

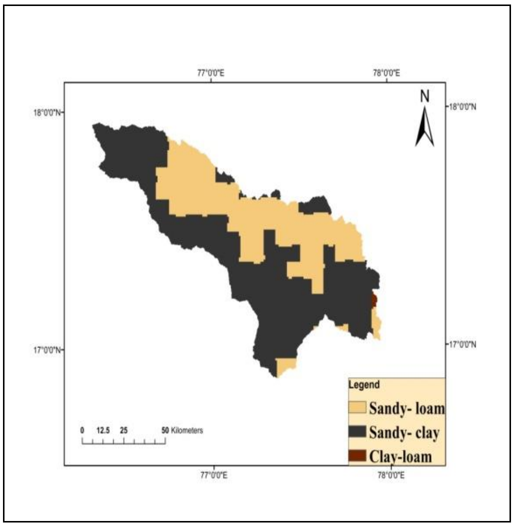

Fig 5 . Soil classes of the study area

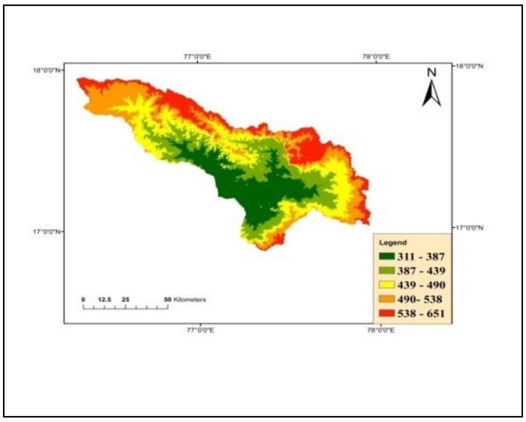

Fig 6 . DEM Map of Bennethora sub watershed

Monthly observed discharge from 1995-2005 for the Malkhed Station; within the assessment area was acquired from Water Resource Information System WRIS 4.0.

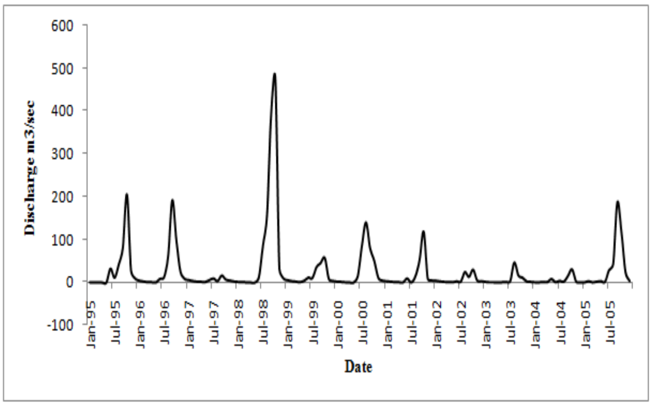

Fig 7 .Average monthly discharge in the Malkhed gauging station (Source: India- WRIS, 2008)

3.2 Calibration and Validation of the SWAT Model

Hydrological modelling is greatly mired by the non availability of good observed data in many Indian watersheds. The SWAT model was calibrated and validated for monthly discharge and sediment yield for only monsoon months of years. The model was calibrated from1995 to 1999 and validated from 2000 to 2005.

Table 3. SWAT Sensitive parameters used during calibration

Variable	Parameters	Initial value	Fitted value
Flow	CN2.mgt	74	92
	ALPHA_BF.gw	0.048	0.05
	EPCO.hru	0.4	10
	SOL_AWC.sol	0.175	0.48
	SOL_Z .sol	300	240
	SURLAG.BSN	4	0.25
	GW_DELAY.gw	80	30
	ESCO.hru	0.4	0.79
	SOL_K.sol	17.78	10
Sediment	SLSUBBUSN.hru	121.95	130
	USLE_P.mgt	1	0.53
	SOL_AWC.sol	0.48	0.15
	Ch_COV.rte	0.0114	0.71
	OV_N.hru	0.15	0.9

4. RESULT'S AND DISCUSSION

4.1 Calibration

Calibration is done by manually, in first step of manual calibration model is run for virgin condition by using monthly discharge data .fig shows comparison of simulated and observed discharge during calibration, the R^2 and NSE for both runoff and sediment are found to be 0.728 and 0.653, and for sediment 0.533 and 0.526 respectively. Following figure shows the comparison of simulated and observed flow and scattered plot of observed vs simulated flow.

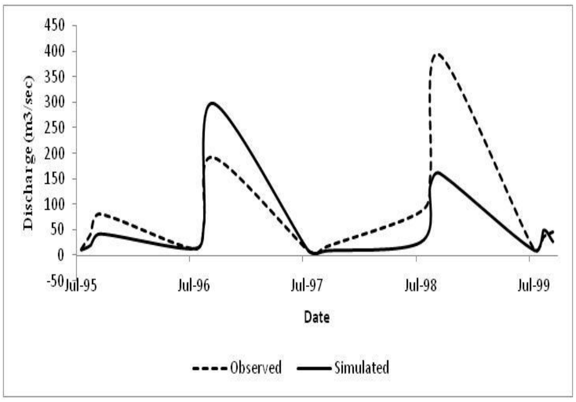

Fig 8: Comparison of observed and simulated discharge values on calibration

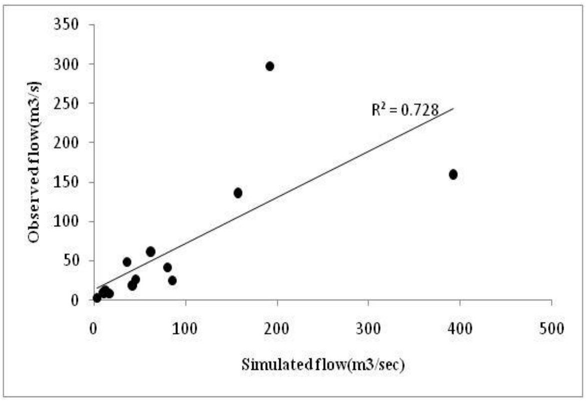

Fig 9: Scatter plot of observed v/s simulated plot on calibration

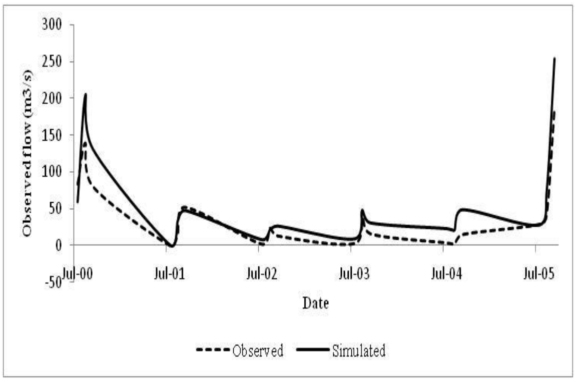

Fig 10: Observed v/s simulated discharge values on validation

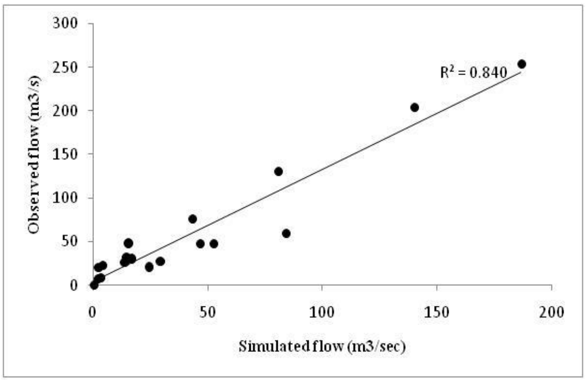

Fig11: Scatter plot of observed vs. simulated flow during validation

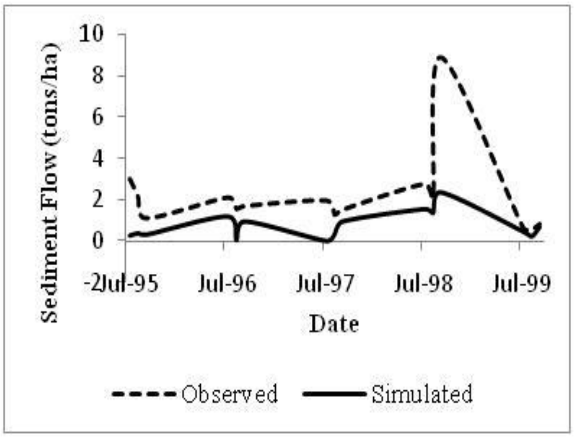

Fig 12: Comparison of observed and simulated sediment values on calibration

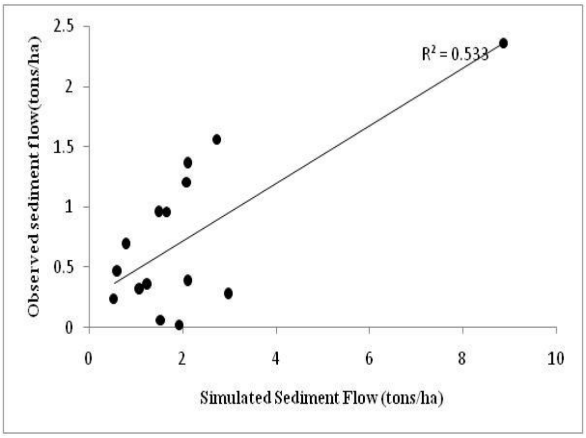

Fig 13: Scatter plot of observed v/s simulated plot on calibration

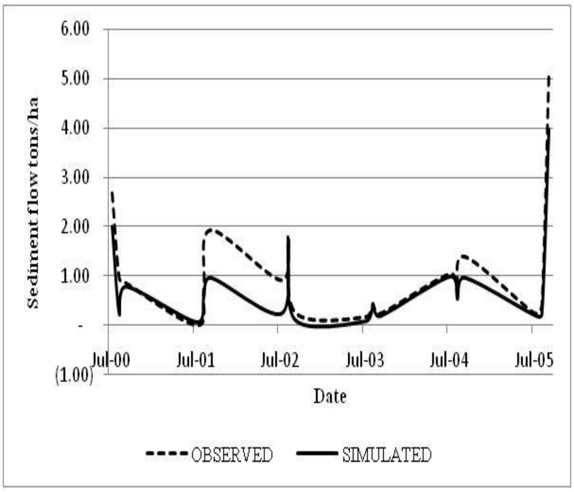

Fig14: Comparison of observed and simulated sediment values on validation

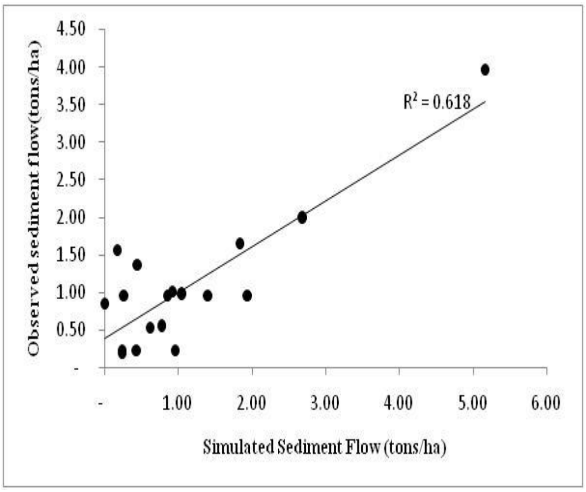

Fig15: Scatter plot of observed v/s simulated plot after validation

Outcomes for both the discharge and sediment calibration and validation for the monthly discharge Malkhed gauge station are shown below Table4.For sediment calibration and validation is done for only monsoon period i.e. July, august and September.

Table4: Results illustrating values for objective functions during the period of calibration and validation

Objective Function	Calibration	Validation
R^2 (Run off)	0.728	0.840
NSE	0.653	0.660
R^2(Sediment)	0.533	0.618
NSE	0.526	0.538

After the calibration 2 Best management practices are adapted to the watershed namely filter strips and stone bunds to evaluate the runoff and sediment transport.

4.2 Impact of Best Management Practices in SWAT

4.2.1 Filter strips

In SWAT modeling the filter strips are adopted on the basis of trapping efficiency of the sediment particles. Filter strips were included into the SWAT model and were simulated over the entire agricultural watershed. The strip width received for the present case are 2m, 5m, and 7m. The decremented diminishment in silt yield for the every one of the case is shown in the underneath figure and the correlation is additionally made as for sediment yield with or without BMP.

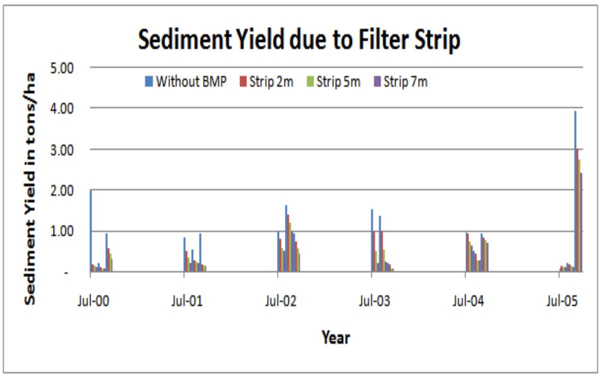

Fig 16: Decreased Sediment Yield due to the Implementation of Filter Strips of Various Widths (1990 -2005)

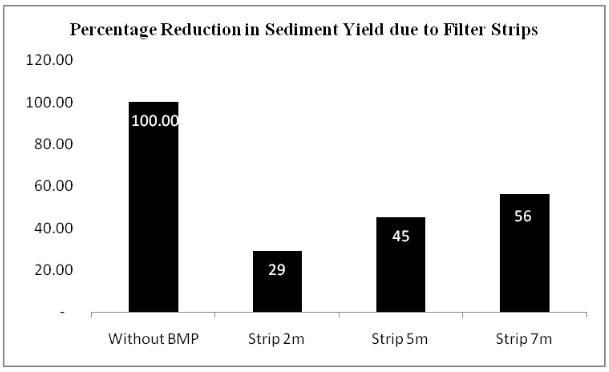

Fig 17 : Percentage reduction in Sediment Yield due to the implementation of Filter Strips of various widths

4.2.2 Stone Bunds

Lying of stone bonds in fields or watershed is a well-known technique to control soil erosion and runoff. It is most widely adopted technique by farmers all over the world. As a result government and non government programs are promote the large scale introduction of the technique. These stone bunds act as barrier which slows down the runoff water, allowing water to percolate into the soil and spread more evenly over the land. This method is particularly suited to semi-arid lands, where stones are available.

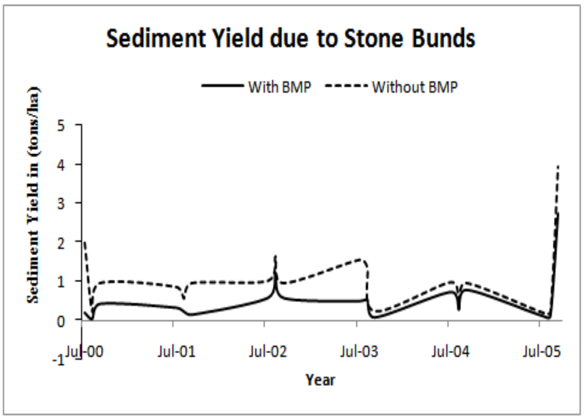

Fig 18 : Decreased Sediment Yield due to the implementation of Stone bunds (1990 -2005)

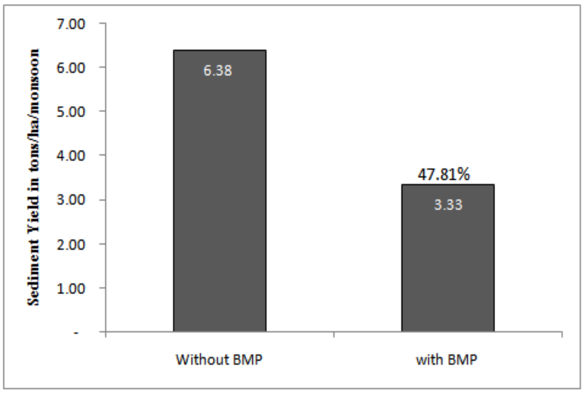

Fig 19 : Decreased Percentage Sediment Yield due to the implementation of stone bunds (1990 -2005)

Table 5: SWAT parameters used in BMP's

Scenarios	Description	Parameter (input)	Calibration value	Modified value
Scenario-1	Filter strip	FILTERW(.hru)	0	2
Scenario-2			0	5
Scenario-3			0	7
Scenario-4	Stone bund	SLSUBBSN(.hru) 0-3% slope 0-7% slope	120 (m) 91	10 10
		CN2 (.mgt)	92	64
		USLE_P(.mgt)	0.53	0.32

5. CONCLUSION

The SWAT model is calibrated for 5 years from 1995 to 1999 and validated from 2000 to 2005. The results obtained from calibration of runoff R^2 and NSE 0.728 and 0.650 respectively & for sediment yield R^2 and NSE 0.533 and 0.526 respectively. During validation for runoff R^2 and NSE values found to be 0.840 and 0.660respectively. For sediment validation R^2 and NSE are 0.618 and 0.538 respectively.

By introducing Filter strips as one of the BMP measure, it was found that increase in filter width leads to a considerable decrease in sediment yield. Additionally it was depict that by adopting filter strip of width 7m there is a diminishment of 56% sediment yield. On implementing stone bunds it was found that, the sediment yield can be reduced up to 47.81%. Hence Stone bunds implementation cost can be reduced if the materials are available near the vicinity. Adaptations of BMP's can decrease sediment yield in the watershed.

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