Performance Evaluation of Gully Plugging Structures in a Watershed of Mungeli District of Chhattisgarh

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ABSTRACT

A study on construction of gully plugging structures and their performance evaluation was carried out at BRSM College of Agricultural Engineering and Technology & Research Station, Chhattisgarh in 2015. Soil and water conservation structures namely single row brush wood, double row brush wood, loose stone, gunny bag and gabion check dam, respectively were constructed and evaluated. It was observed that importance of gully control structures by reducing the original gradient of the gully channel and the structures were diminished the velocity and the erosive power of runoff and recharged the ground water. Run-off during peak flow has been conveyed safely by check-dams. It was also observed that successful runoff reduction and sediment deposition in upstream side also. The performance of the structures was evaluated on the basis silt deposition and percentage depth of water ponding. The total silt deposition in upstream side of gully plugging structures was found to be 90.51 quintal which indicates the good features of soil conservations. The maximum 39.58 quintals sediment deposition was observed in upstream side of loose stone structures wile minimum of 7.85 quintals was recorded in double row brush wood structure. The maximum percentage depth of water ponding of 90% in gunny bag structure and minimum depth of water ponding 60% in single row brush wood structure.

Keywords

Gully, brush wood, loose boulder, gunny bag, gabion, Mungeli

INTRODUCTION

Soil erosion is one of the major problems confronting agriculture worldwide. It is a major threat to the soil resource, soil fertility, productivity, and, lastly to food and fiber production, mainly on farm. As it is known by many, gully erosion is the worst form of erosion that apart from snatching fertile lands is the main source of sediment load arriving at reservoirs. The spread of gully is seen as cancer affecting many communal grazing spots, foot paths, cattle trafficking lines, roads, etc. It also obstructs field operations and movement. The subsoil and gravel mined by erosion is a major threat on lower lying fertile agricultural fields by burying them under. A lot of farmers' fields are presently affected and complaining that their lands have been taken away by debris which they cannot remove. Many low-lying areas and public infrastructure facilities have been overburdened /overlaid by subsoil which is not fertile. The subsoil is composed of course sand, gravel, cobbles and boulders. Although there are many on-going efforts carryon by the various supporting projects and the regular government's land management program to rehabilitate gullies, the scale at which it is expanding has not been adequately coped up with the existing level of treatment. Pendake (2009) carried a study on qualitative performance of different soil and water conservation structures in Daregaon watershed, Maharashtra. Sikarwar *ea al* (2012) analysed that construction of the check dams enhanced d the crop yields and corresponding benefits in Junagadh District (Gujarat)**.** Keeping in view the above facts, a study on design and construction of gully control structures for soil and water conservation was carried at BRSM College of Agricultural

Engineering and Technology & Research Station, Chhattisgarh in 2015.

MATERIALS AND METHODS

Study Area

The construction of gully plugging structures was carried out in field of College Campus, BRSM CAET and RS IGKV, Mungeli located on Village Chatarkhar, District Mungeli Chhattisgarh. It is located on Latitude 22^{o} 03'N, Longitude 81^{0}38'E and at a altitude of 287 m. The area of the campus is 13 ha out of which 9 ha is used for cultivation and 4 ha land has been used for infrastructure of college and average slope less than 2 %.

Design and construction of gully plugging structures

1. Estimation of peak rate of runoff: The peak runoff rate from the watershed area was estimated by using rational formula.

The peak runoff rate from the catchment area was estimated by using Rational method

$$Q = \frac{CxIxA}{360} \quad \ldots(1)$$

Where,

Q = Peak runoff rate, m^3/s;

C = Coefficient of runoff;

I = Average intensity of precipitation for a duration equal to time of Concentration mm/hr;

A = Drainage area (ha). Co-efficient of runoff 'C' was computed by taking into consideration the soil texture, vegetative cover and slope [2] (Suresh, 2012).

Average intensity of precipitation for duration to time of concentration was calculated by using intensity-duration-return period relationship.

$$I = \frac{KT^{a}}{(t_c+b)^{n}} \quad \ldots(2)$$

Where,

I = Average intensity of precipitation cm/hr;

T = Return period, years;

t_c = Storm duration, hrs

k, a, b and n are constants.

The values of these constant for study area were selected as recommended by [2] (Suresh, 2012).

K= 4.683, a = 0.1389, b =0.15 and n = 0.9284

Time of concentration of the catchment area was estimated by Kirpich's

$$t_c = 0.01947\ L^{0.77}\ S^{-0.385} \quad \ldots(3)$$

Where,

t_c = Time of concentration, hours.

L = Length of channel reach, m and

S = Average slope of channel reach, m/m.

2. Determination of dimension of structures: Dimensions of different gully plugging structure (Single row brush wood dam, Double row brush wood dam, loose boulder check dam, gunny bag structures and gabion structures) were determined based on guide lines and principles suggested by Murthy (2011).

3. Construction of structures: Locally materials available were procured for construction. For construction brush wood dam, we used wastage and broken fencing poles which were procured for fencing college campus in place of wooden poles. Again wire mesh for gabion structures was procured wastage wire mesh used for college fencing. Other materials such as boulders and ipomea sticks were available near the field. Empty gunny bags from newly being constructed college buildings were collected. Sand or pebbles were also collected from same buildings site as wastage after grading for use.

Site selection and layout: Single row brush wood dam, Double row brush wood dam, loose boulder check dam, gunny bag structures and gabion structures were selected for construction. Site selected based on visual observation at field. Layout was done for construction of different structures.

Observations taken for performance evaluation of structures

Measurement of silt deposition:

The data on silt deposition i.e. depth of silt deposited in the storage area, were collected. For this, small pits were made in impounding area of the structure up to a depth of original ground surface at different locations and an average depth of silt was deposited was determined. The area of silt deposited was measured by dividing it into regular triangles and rectangles. Volume of silt deposited was measured by multiplying the area of silt deposition and depth of deposited. Weight of silt deposited was calculated by multiplying the volume of silt by bulk density of silt. The bulk density of silt was found to be 1.35. gm/cc.

Measurement of Depth of water ponding:

Depth of water ponding in percentage was determined by measuring the depth of water ponding in upstream side of each structure. It was calculated by the given formuale

Depth of water ponding (%) = (Water ponding depth)/ (Design depth of structure) x 100

The present dimensions of the structure i.e. top width, bottom width, height and cross-sectional area were recorded. The data on silt deposition i.e. depth of silt deposited in the storage area and area of silt deposition were collected. Volume and weight of the silt deposited were determined for evaluating the efficiency of the structures with respect to retention of soil loss from the area.

RESULTS AND DISCUSSIONS

Designing and construction of different gully Plugging structures

In gully control, there were five different temporary physical structural measures such Single row brush wood structure, double row brush wood structure, loose stone structure, gunny bag structure and gabion structure were contracted to dissipate the energy of runoff and to keep the stability of the gully in the watershed as shown in Fig1- 5. and Table 1.

These structures were constructed across the gully bed to stop channel/bed erosion also. By reducing the original gradient of the gully channel, these structures were diminished the velocity of water flow of runoff and the erosive power of runoff. Run-off during peak flow rate 0.48 m^3 /s has been conveyed safely by check-dams. Temporary check-dams, which have a life-span of three to eight years, collected and hold soil and moisture in the bottom of the gully. This helped to give vegetation an opportunity to establish in the gully. These structures are selected based on the amount of the runoff and the status of the gully whether young and actively eroding or mature and establishing naturally.

Table 1: Specification and cost of different gully plugging structure

S.No.	Types of Structures	Length (m)	Height (m)	Width (m)		Weight of sediment deposition (quintal)	Depth of ponding (%)	Cost (Rs)
1	Single row brush wood	5.80	1.0	0.30		7.87	60	410
2	Double row brush wood	5.90	1.0	0.90		7.85	70	630
3	Loose stone	6.20	1.0	Top	Bottom	39.58	75	666
				0.90	1.80			
4	Gunny bag	6.40	1.0	**1.0**		15.87	90	600
5	Gabion	6.50	1.0	Top	Bottom	19.34	80	670
				0.70	1.50			

Performance Evaluation of Different Gully Plugging Structures

Silt deposition at different structures

Data on silt deposition at single row brushwood, double row brushwood, loose stone structure, gunny bag structure and gabion structure are presented in table 1 .From the table it is founded that average depth of silt deposition at single row brushwood, double row brushwood, loose stone structure, gunny bag structure and gabion structure are 0.015m, 0.012 m, 0.032 m, 0.021m and 0.023m, respectively. Silt deposition of 39.58 quintal was maximum in upstream side of structure of loose stone structure and while minimum of 7.85 quintal was observed in double row brushwood structure .The total 90.51 quintal of silt was arrested by five gully control structures. This silt deposition is a good feature of soil conservation. The data of silt deposition at different structures are presented in table1 and Fig 6.

Fig 1: Single row brush wood dam

Fig 2: Double brush wood dam

Fig 3: Loose boulder structures

Fig 4: Gabion structure

Fig 5: Gunny bags structure

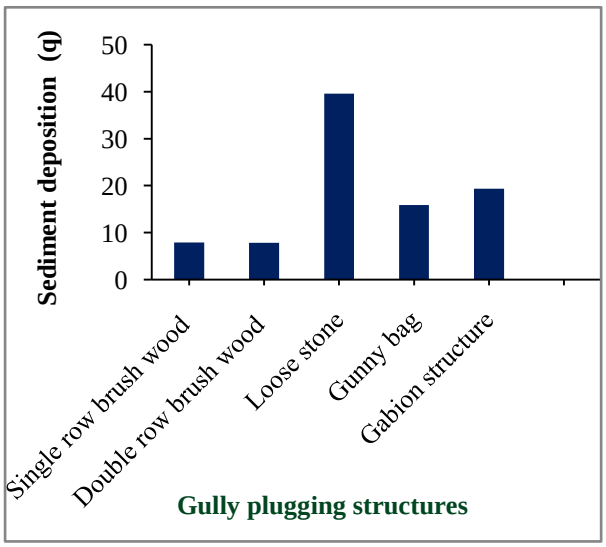

Fig 6: Sediment deposition at different structures

Depth of water ponding

Depth of ponding at single row brushwood, double row brushwood, loose stone structure, gunny bag structure and gabion structure are presented in table 1. From the table it is clear that average depth of water ponding at single row brushwood, double row brushwood, loose stone structure, gunny bag structure and gabion structure were 60%, 70%, 75%, 90% and 80%, respectively. 90% water ponding in upstream side of gunny bag structure was maximum structure and 60% minimum in double single brushwood structure .The average water ponding 75% is found by five gully control structures. This water ponding is helpful for ground water recharge.

CONCLUSION

Based on the study it can be concluded that the total silt deposition in upstream side of gully plugging structures was found to be 90.51 quintals in average area over the period of 6 month indicate the good features of soil conservations. The maximum 39.58 quintals sediment deposition was observed in upstream side of loose stone structures wile minimum of 7.85 quintals was recorded in double row brush wood structure. The maximum percentage depth of water ponding of 90% in gunny bag structure and minimum depth of water ponding 60% in single row brush wood structure. Run-off during peak flow has been conveyed safely by designed and constructed structures. Hence these low cost structures are very useful reduction in runoff reduction and deposition in sediment in upstream side.

REFERENCES

[1] Murty V.V.N. and Jha M .K. 2011. Land and water Management Engineering. Kalyani publishers, New Delhi.

[2] Pendke M.S. 2009. Quality evaluation of soil and water conservation structure in Daregaon watershed, *Journal of Soil and Water Conservation*, 8(1):9-13

[3] Sikarwar R. S., Khandelwal M.K. and Arora S (2012). Performance of Rainwater Harvesting Structures in a Watershed of Junagadh District (Gujarat) *Journal of Soil and Water Conservation*, 11(2) :129–132

[4] Suresh R. 2012. Soil and Water Conservation Engineering. Standard Publication New Delhi.