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ORIGINAL ARTICLE

Water Quality Parameters Varying after Different Intervals at Selected Land Slopes under Simulated Rainfall Conditions

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ABSTRACT
The sediment outflow and water quality parameters (TDS, pH and EC) at different times as 1st, 5th, 9th and 13th day after starting the experimentat varying land slopes under simulated rainfall intensities for bare land were observed. The study was conducted under laboratory condition with 3.77 cm/h, 8.82 cm/h and 12.73 cm/h rainfall intensity and 0%, 2%, 4%, 8% and 12% of land slopes with bare land. The effects of various combinations of input variables on water quality parameters and sediment outflow were observed. The pH values of runoff water upto 5th day and the TDS values upto 13th day after starting the experiment were recorded to be higher at every combination of land slope and rainfall intensity. The EC values till 13th day after starting the experiment were found to be higher at every combination of rainfall intensity and land slope but the water quality parameters (TDS, pH, EC and sediment outflow were found to be the increasing of time duration the observed values decreases. The mathematical relationships were also developed between water quality parameters ((TDS, ppm), (pH), and (EC, µs)) with sediment outflow (So, mg/m²/min), and various input variables for bare land treatments and found to be good correlation.
Keywords: *TDS, pH, EC, Portable Rainfall Simulator, Sediment outflow, Land slopes, Rainfall intensity*

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INTRODUCTION

Maintain of runoff water quality parameters is a serious concern of environment, as the decrease of runoff water quality parameters results in the reduction of fertility level of soil which affects the plants' life adversely. The water quality parameters is quite closely correlated with the occurrence of runoff, soil erosion and sediment outflow [4]. On the other hand, the decreasing of quality of water with runoff from the fields is directly affected on soil and human being [3, 6, 1]. The accumulation of chemicals in these water bodies produce harmful toxic effects rendering it unfit for human as well as for animal consumption and also has negative effects on agricultural and aquacultural eco-systems [2, 5, 10]. Runoff samples were collected and analysed for every combination of input variables to determine sediment outflow and water quality parameters which include total dissolved salts (TDS), pH and electrical conductivity. The effect of runoff water quality parameters under varying rainfall intensity at different land slopes. Data recorded during experimentation were subjected to analysis and presentation to visualise the effect of runoff water quality parameters with varying land slope at different times after urea applications. To quantify the effect of involved variables on sediment outflow and water quality parameters, mathematical relationships were also developed for various combinations of the input variables. Portable rainfall simulation system helped to conduct these studies under actual field conditions with enhanced quality of hydrologic control over various constraints faced with natural rainfall [8, 9]. Observations were made for bare soil land, at different times as 1st, 5th, 9th and 13th day after starting experiment on 0%, 2%, 4%, 8% and 12% land slopes under simulated rainfall at intensities of 3.77, 8.82 and 12.73 cm/h. the rainfall duration of 10 minutes are fixed for all experiment.

MATERIAL AND METHODS

The experiment was carried out on the five runoff plots to maintain the soil characterizes. In this study using a portable rainfall simulator and experimental plots. The experimental set-up as shown in Fig. 1, basically includes a portable rainfall simulator of 3.4 m ×1.4 m size for generating simulated rainfall and five experimental plots of 3 m ×1 m size. The study was conducted under laboratory conditions due to

the possibilities of simulating different rainfall intensities with the necessary repetition as well as minute study of the sediment outflow, runoff processes and data collection under varying hydrologic and land treatment conditions.

Fig. 1 The experimental set-up

Determination of (TDS) total dissolved salts

Presence of total dissolved salts is an important quality parameter of runoff water. The presence of these dissolved salts and ionized solids, increase the conductivity of a solution. A TDS meter was used to measure the TDS of the solution.

Measurement of pH

Samples for measurement were taken from the runoff collectors. The pH was analysed with the help of pH meter shoes.

Measurement of electric conductivity (EC)

Electric conductivity of runoff water was recorded by using electric conductivity analyser meter. Conductivity is nothing but the ease with which electricity passes through the solution and is an indicator of presence of salts in soil. Electric conductivity cell was also calibrated at specific conditions for known conductivity of 0.1 N KCL solution. Conductivity of runoff water was recorded putting conductivity electrode in sample beaker, then it was flushed and put in the distilled water.

Determination of sediment outflow

The collected runoff samples were analysed for presence of sediment by oven dry method. The collected 100 cc runoff samples were put in circular aluminum containers with 75 mm diameter of 150 ml capacity and of known weight to be put in an electric oven for 24 h, at 105˚C to determine the sediment concentration.

RESULT AND DISCUSSION

The study was conducted in a laboratory to determine water quality parameters and sediment outflow with varying land slopes under simulated rainfall conditions. The runoff was collected and analysed for sediment outflow and water quality parameters.To observe and quantify the effect of nitrogen release on water quality parameters the values of TDS, pH and electrical conductivity of runoff water from barren land were observed on1st,5th,9th and 13th day after starting experiment at 0%, 2%, 4%, 8% and 12% land slopes under simulated rainfall at intensities of 3.77, 8.82 and 12.73 cm/h. the rainfall duration of 10 minutes are fixed for all experiment.

Table 1 Observed sediment outflow and runoff water quality parameters with bare soil conditions [on 1st day under simulated rainfall conditions]					
Land slope, (%)	Rainfall intensity, (cm/h)	Average sediment outflow rate, (mg/m²/min)	Water quality parameters		
			pH	EC, (µs)	TDS, (ppm)
0	3.77	2240	8.20	669	351
	8.82	5544	8.20	674	355
	12.73	6733	8.10	686	363
2	3.77	3444	8.20	674	406
	8.82	8382	8.20	678	458
	12.73	13776	8.10	740	468
4	3.77	5215	8.30	740	436
	8.82	17397	8.30	738	432
	12.73	25422	8.20	775	452
8	3.77	8992	8.10	839	494
	8.82	22256	8.10	833	487
	12.73	33397	8.10	852	495
12	3.77	9817	8.30	849	506
	8.82	25830	8.20	947	498
	12.73	35049	8.20	999	526

Observed TDS of runoff water from bare land on different times at selected land slopes under simulated rainfall conditions

To observe TDS values of runoff water, its samples were collected and analysed. The values of TDS of runoff water were observed in collected samples which were collected under varying simulated rainfall intensities at particular land slope at different times. The observed values on 1st, 5th, 9th and 13thdays after starting experiment are presented in Table 1 to 4.

Table 2 Observed sediment outflow and runoff water quality parameters with bare soil conditions [on 5th day under simulated rainfall conditions]					
Land slope, (%)	Rainfall intensity, (cm/h)	Average sediment outflow rate, (mg/m²/min)	Water quality parameters		
			pH	EC, (µs)	TDS, (ppm)
0	3.77	2228	8.10	678	358
	8.82	4913	8.00	663	348
	12.73	5704	8.00	672	374
2	3.77	3120	8.30	699	398
	8.82	7857	8.20	671	452
	12.73	10859	8.20	751	461
4	3.77	5002	8.40	759	432
	8.82	17485	8.30	728	426
	12.73	23069	8.30	806	444
8	3.77	8058	8.20	802	446
	8.82	20412	8.30	811	463
	12.73	28992	8.10	826	477
12	3.77	9297	8.30	795	467
	8.82	25494	8.30	887	488
	12.73	32680	8.10	903	494

On 1stday it was observed that the TDS values at 0% slope ranged from 351 ppm to 363 ppm for the selected rainfall intensities. It ranged from 406 to 468 ppm for 2% land slope, 436 to 458 ppm for 4% land slope, 494 to 495 ppm for 8% land slope and 506 to 526 ppm at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 and 12.73 cm/h. Similarly, 5th day after urea application the observed TDS values of runoff water ranged from 358 to 374 ppm at 0% land slope, 398 to 461 ppm for 2% land slope, 432 to 444 ppm for 4% land slope, 446 to 477 ppm for 8% land slope and 467 to 497 ppm at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 and 12.73 cm/h. On 9th day after the observed TDS values of runoff water ranged from 328 to 389 ppm at 0% land slope, 318 to 413 ppm for 2% land slope, 421 to 439 ppm for 4% land slope, 398 to 465 ppm for 8% land slope and 459 to 481 ppm at 12% land slope for the selected range of simulated rainfall intensities. It was observed that on 13th day after urea application the maximum observed TDS values of runoff water was found to be 480 at

a land slope of 12% for the rainfall intensity of 12.73 cm/h and minimum TDS value of 317 was found at 0% land slope for the simulated rainfall intensity of 3.77 cm/h. The minimum and maximum TDS values ranged from 317 to 357 ppm at 0% land slope, 319 to 399 for 2% land slope, 384 to 424 ppm for 4% land slope, 453 to 458 for 8% land slope and 449 to 480 ppm at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 ppm and 12.73 cm/h. A close insight to the observed data clearly indicated that in general the average TDS value of runoff water gradually increased from 351 ppm to 526 ppm on 1st day, 358 ppm to 494 ppm on 5th day, 318 ppm to 481 ppm on 9thday and 481 ppm to 480 ppm on 13th day when simulated rainfall intensity was varied from 3.77 to 12.73 cm/h for land slopes of 0%, 4%, 8% and 12% respectively. The TDS values were found to be increasing with land slope as well as with rainfall intensity which is very closely related with sediment outflow pattern. To have a visual comparison of variation in TDS values, the observations are plotted graphically and is shown in Fig. 4.

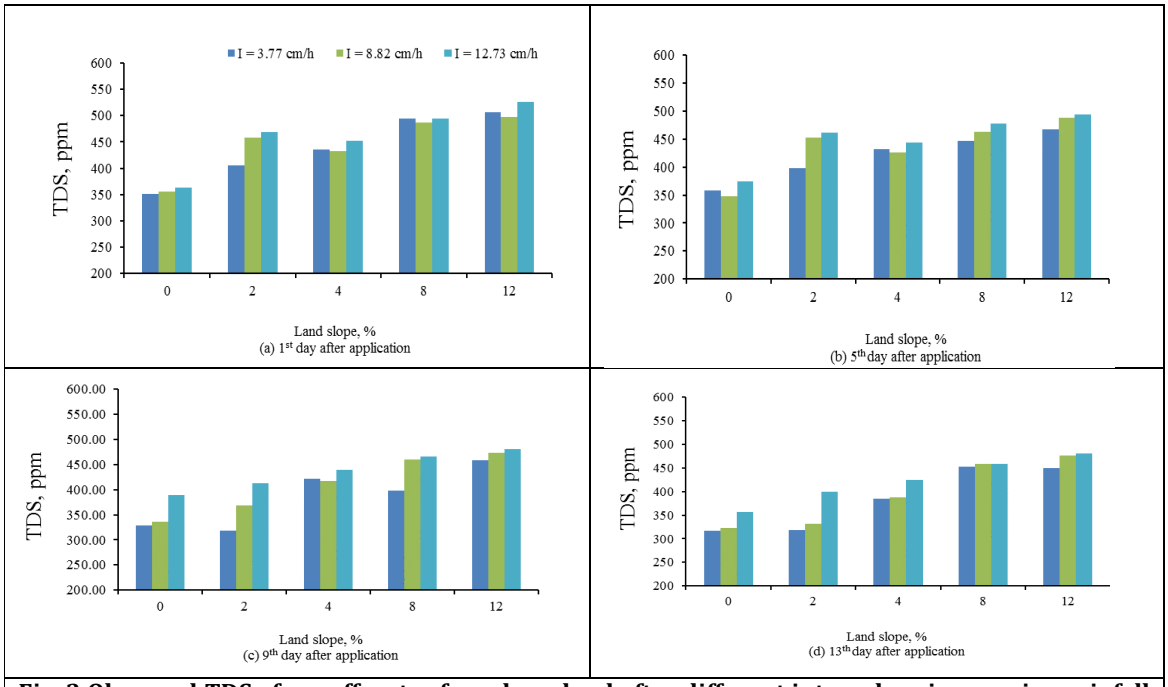

Fig. 3 Observed TDS of runoff water from bare land after different intervals using varying rainfall intensity at selected land slopes

Table 3 Observed nitrogen retained/release, sediment outflow and runoff water quality parameters [with bare soil conditions on 9th day under simulated rainfall conditions]

Land slope, (%)	Rainfall intensity, (cm/h)	Average sediment outflow rate, (mg/m²/min)	Water quality parameters		
			pH	EC(µs)	TDS(ppm)
0	3.77	2023	7.90	636	328
	8.82	5003	8.00	649	336
	12.73	6412	8.00	694	389
2	3.77	2966	8.00	694	318
	8.82	8285	8.00	663	369
	12.73	12315	8.10	758	413
4	3.77	4383	8.00	712	421
	8.82	16572	8.00	726	417
	12.73	24093	8.10	797	439
8	3.77	7334	8.10	785	398
	8.82	22083	8.10	804	447
	12.73	30267	7.90	821	465
12	3.77	8543	8.00	778	459
	8.82	25813	8.20	824	473
	12.73	32785	7.80	869	481

Observed pH from bare land after different times at selected land slopes under simulated rainfall intensities

The pH values of runoff water were observed, its samples were collected and analysed. The values of pH of runoff water were observed in collected samples which were collected under varying simulated rainfall intensities at particular land slope at different times. The Observed values on 1st, 5th, 9th and 13thdays are tabulated in Table 1 to 4. From Fig. 4 the observed data clearly indicated that in general the average pH value of runoff water gradually increased from 8.10 to 8.30 on 1st day, 8.00 to 8.40 on 5th day, 7.80 to 8.20 on 9th day and 7.70 to 8.10 on 13th day when simulated rainfall intensity was varied from 3.77 to 12.73 cm/h for land slopes of 0%, 4%, 8% and 12% respectively, and from Fig. 4. is shows that, in general, pH values were found to be decreasing with increasing time intervals, however, no correlation was observed with rainfall intensity and land slope.

Table 4: Observed nitrogen retained/release, sediment outflow and runoff water quality parameters [with bare soil conditions on 13th day under simulated rainfall conditions]

Land slope, (%)	Rainfall intensity, (cm/h)	Average sediment outflow rate, (mg/m²/min)	Water quality parameters		
			pH	EC, (µs)	TDS, (ppm)
0	3.77	1855	7.90	621	317
	8.82	5467	7.80	633	323
	12.73	6944	7.80	676	357
2	3.77	2935	7.90	667	319
	8.82	8078	7.90	636	332
	12.73	12462	8.00	749	399
4	3.77	3827	8.00	721	384
	8.82	15172	7.90	684	388
	12.73	21765	7.80	769	424
8	3.77	7593	7.90	755	453
	8.82	24053	8.00	779	458
	12.73	30681	7.80	787	458
12	3.77	8335	7.90	768	449
	8.82	28482	8.10	793	476
	12.73	31506	7.70	818	480

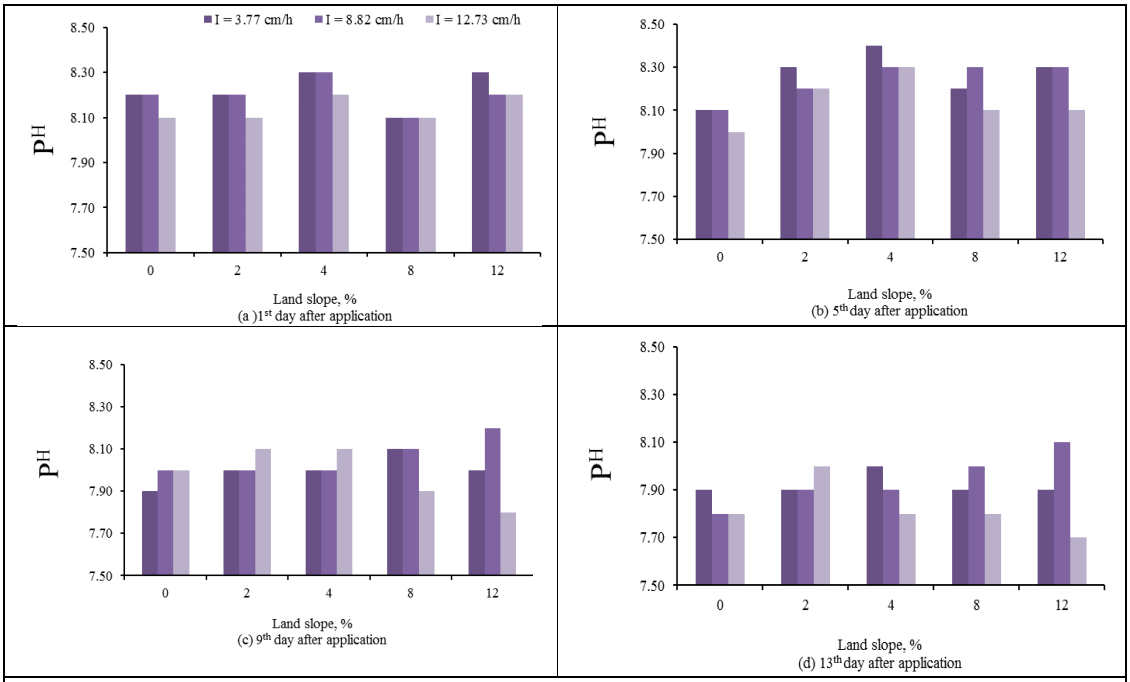

Fig. 4 Observed pH of runoff water from bare land after different intervals using varying rainfall intensity at selected land slopes

Observed EC from bare land after different times at selected land slopes under simulated rainfall intensities

The observed values of (EC) electrical conductivity on 1st, 5th, 9th and 13th days after starting experimentare presented in Table 1 to 4. The average values of EC of runoff water were observed, its samples were collected and analysed. The values of EC of runoff water were observed in collected samples which were collected under varying simulated rainfall intensities at particular land slope at different times. On 1st day it was observed that the EC values at 0% slope varied from 669 to 686 µs for the selected rainfall intensities. It ranged from 674 to 740 µs for 2% land slope, 738 to 775 µs for 4% land slope, 833 to 852 µs for 8% land slope and 849 to 999 µs at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 and 12.73 cm/h. Similarly, 5th day the observed EC values of runoff water varied from 663 to 678 µs at 0% land slope, 671 to 751 µs for 2% land slope, 728 to 806 µs for 4% land slope, 802 to 826 µs for 8% land slope and 795 to 903 µs at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 and 12.73 cm/h. On 9th day the observed EC values of runoff water varied from 636 to 694 µs at 0% land slope, 663 to 758 µs for 2% land slope, 712 to 797 µs for 4% land slope, 785 to 821 µs for 8% land slope and 778 to 869 µs at 12% land slope for the selected range of simulated rainfall intensities. It was observed that on 13th day the maximum observed EC value of runoff water was found to be 818 µs at a land slope of 12% for the rainfall intensity of 12.73 cm/h, and minimum EC value of 621 µs was found at 0% land slope for the simulated rainfall intensity of 3.77 cm/h. The minimum and maximum values ranged from 621 to 694 µs at 0% land slope, 636 to 758 µs for 2% land slope, 712 to 806 µs for 4% land slope, 755 to 852 µs for 8% land slope and 778 to 999 µs at 12% land slope for the selected simulated rainfall intensities of 3.77, 8.82 and 12.73 cm/h. The observed data clearly indicated that the average EC values of runoff water gradually increased from 669 to 999 µs on 1st day, 663 to 903 µs on 5th day, 636 to 869 µs on 9th day and 621 to 818 µs on 13th day after starting experiment, when simulated rainfall intensity was varied from 3.77 to 12.73 cm/h for land slopes of 0%, 4%, 8% and 12% respectively. The EC values were found to be increasing with land slope as well as with rainfall intensity which is very closely related with TDS pattern. To have a visual comparison of variation in EC values, the observations are plotted graphically and is shown in Fig. 5. The non- linear and non-constant mathematical relationships between water quality parameters ((TDS, ppm), (pH), and (EC, µs)) with sediment outflow (So, mg/m²/min) and various input variables for bare land treatments were found to be good correlation.

$$So = 3.116 \text{ Log TDS} - 15.349 \text{ Log pH} + 3.189 \text{ Log EC}$$
$$R^2 = 0.998$$

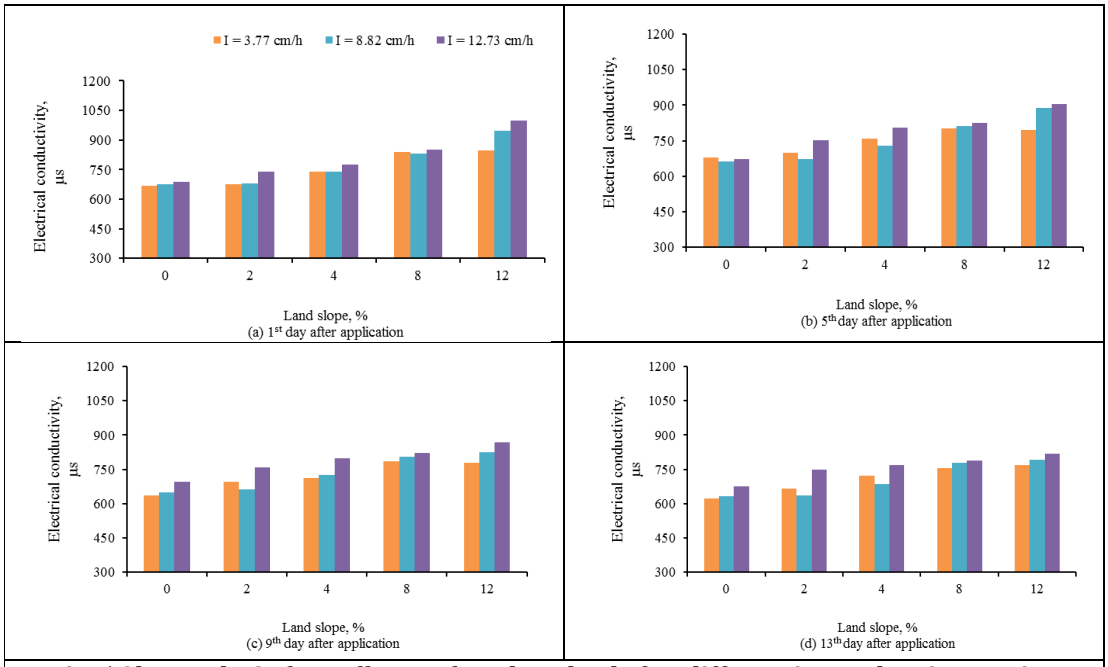

Fig. 5 Observed EC of runoff water from bare land after different intervals using varying rainfall [intensity at selected land slopes]

CONCLUSION

The water quality parameters (TDS, pH and EC) and sediment outflow at different times as 1st, 5th, 9th and 13th day after starting the experiment for varying land slopes under simulated rainfall intensities for bare land were carried out. The study was conducted under laboratory condition with 3.77 cm/h, 8.82 cm/h and 12.73 cm/h rainfall intensity and 0%, 2%, 4%, 8% and 12% of land slopes from bare land. The effects of various combinations of input variables on water quality parameters and sediment outflow.The pH values of runoff water upto 5th day and the TDS values upto 13th day after starting the experiment were recorded to be higher at every combination of land slope and rainfall intensity. The EC values till 13th day after starting the experiment were found to be higher at every combination of rainfall intensity and land slope. The pH values of runoff water upto 5th day after starting the experiment were recorded to be higher at every land slope. The scenario of water quality parameters (TDS, pH and EC) and sediment outflow were found to be decreasing, when the increasing of time duration. The mathematical relationships between water quality parameters ((TDS, ppm), (pH), and (EC, µs)) with sediment outflow (So, $mg/m^2/min$) and various input variables for bare land treatments were found to be good correlation ($R^2 = 0.998$).

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