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Research Article

EFFECT OF WATER PONDING DEPTHS ON SOIL NUTRIENT LOSS AND LEACHATE WATER QUALITY UNDER EXPERIMENTAL CONDITIONS

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ABSTRACT
The current study demonstrates the effect of water ponding depths on soil nutrient losses due to the percolation of water and study also evaluates the water quality of the the leachate received. The study was conducted on small experimental plots of size (1 m x 1 m x 0.5 m) under laboratory conditions by using a rainfall simulator to produce the desired range of rainfall intensity. The predetermined doses of fertilizer were applied to the field to meet the field requirement of 300 kg N/ha, 120 kg P/ha and 80 kg K/ha. The three water ponding depths of 5 cm, 10 cm and 15 cm were used to compare their effects on nutrient concentration (ammonia nitrogen, phosphorus, potassium) and water quality parameters on leachate water. The concentrations of ammonia nitrogen and potassium in percolated water were found to have a decreasing trend with time for every depth of water ponding while the concentration of phosphorus was found to be increasing with time for first few hours in leachate thereafter started decreasing. The values of EC and pH in leachate water were also found to be decreasing with time in each case.

Keywords: *Water Ponding Depths, Nutrient Loss, Water Quality, Percolated Water*

INTRODUCTION
In the era of globalization, the farmers are intended to boost their production through intensification and commercialization of agriculture and tempted to use more and more chemical fertilizers to earn higher profit to stand in the comparative environment.
Precipitation in the form of rainfall causes runoff as well as infiltration of water which involves the extraction and movement of useful chemicals from the soil surface with lateral and downward moving water. With the commercialization of agriculture where making profits has become the way of life, farmers are tempted to apply an increased amount of chemical fertilizers to boost their production level. The increased rate of fertilizer application and consequently the increased rate of nutrient loss from the agricultural lands is a serious cause of concern worldwide both from economic and environmental point of view.
Studies of nutrient movement have been conducted on bigger (Caporali *et al.*, 1981) and small watersheds (Schuman *et al.*, 1973; Alberts *et al.*, 1978; Hubbard, 1975; Alberts *et al.*, 1981; Hubbard *et al.*, 1982). Such studies were designed to determine the net effects of agricultural practices with time on nutrient loss and on surface runoff water quality parameters measured at watershed outlet. Sediment out flow through runoff being the most crucial channel among all channels of nutrient loss deserves an important emphasis for conducting specific studies in detail.
Padmaja and Koshy (1978) assessed that 70% of applied urea was lost when field was drained on the day of urea applied. The field determination of nutrient loss in the form of leachate due to downward movement of water from small or large watershed could be very difficult because of very limited control over the timing and sequence of rainfall events.
Several experimental studies were also conducted in past few years using laboratory conditions (Kleinman *et al.*, 2004; Vahabi and Nikkami, 2008; Grismer, 2012; Ries *et al.*, 2013; Kibet *et al.*, 2014) to understand the complex behaviors of hydrological system, rainfall-runoff relationship, understanding soil erosion and infiltration process.
The present study evaluated the soil nutrient downward movement due to different water ponding depth

in order to enhance the efficient utilization of soil nutrients and assessed the subsequent impact of nutrient transport on water quality parameters.

MATERIALS AND METHODS

Experimental Set-up

The experimental set-up mainly consists of a three experimental soil box of size (1.00 m × 1.00 m × 0.5.00 m) placed on hydraulic tilting flume. The experimental soil boxes are maintained up to the soil depth of 50cm and were observed for the effect of water ponding of different depth on nutrient leaching and the water quality received in leachate water.

As the knowledge about various properties of the soil used for conducting the study was imperative as the downward movement of water would be different for different soil materials under similar operating conditions.

The properties like, bulk density, permeability, infiltration rate, porosity, water holding capacity organic matter content, pH, textural class and soil composition (sand, silt and clay in %) were observed as following:

Table 1: Properties of Experimental Soil

Soil Property	Value
Sand: Silt: Clay	51.6: 30.0:18.4
Textural Class	Sandy Loam
Bulk Density	1.68 g/cm3
Permeability	5.2 × 10-5 cm/sec
Infiltration Rate	1.1 cm/h
Water Holding Capacity	31.40%
Porosity	45%
Organic Matter Content	1.46%
PH	7.2

Soil horizon of the experimental plot comprised of locally available sandy material was used as filter of 5-cm thickness. Filter facilitates the downward movement of infiltrated water through the overlain soil of 50-cm thickness.

The experimental soil box has the facility of collecting the leachate of the plot under experiment. Mild steel Tray with a single outlet has been used which is along the slope of the plot to collect the leachate. The soil boxes were filed with soil evenly and proper compression is given to the soil after packing the soil in each experimental plot

Nitrogen, phosphorus and potassium doses were applied as 300, 120 and 80 kg/ ha respectively in the form of UREA, DAP and MOP, which is nearly close to the recommended dose to different crops such as sugarcane, potato, wheat etc.

Simulated rainfall of 9.00-cm/h intensity for one-minute duration was applied on the fertilized plot without creating the runoff condition.

This rainfall application helps the fertilizer to dissolve and well mix and to seep down considerably to avoid easy removal of fertilizer for the period of ½ -h rainfall.

To compare the N, P, K loss of three different treatments, it was necessary to maintain the uniform conditions throughout the experiment. The experimental processes were started post 24 h of fertilizer application.

Experimental Treatments:
The selected experimental treatment with details of input and output parameters are mentioned in Table 2.

Table 2: Experimental Procedure and Details of Observed Experimental Data

Water Depth In Experimental Plot (cm)	Percolation Time Interval for Observation (h)	No. of Events	Observed Experimental Data
5 cm	1	3	1.Percolation rate 2.Ammonia leaching (NH_{4+})
10 cm	1	3	3.Phosphate Leaching(PO_4) 4.Potesium Leaching
15cm	1	3	5.Water Quality such as EC and PH

Determination of Nutrient in Leachate Water & Water Quality Parameters
The ammonia leaching was determined by Nitrogen Analyzer which was highly precise and programmed for the most suitable procedure.
The phosphate leaching in extract was calculated calorimetrically with blue ammonium molybdate method with ascorbic acid as a reducing agent (USDA, 2004). The potassium leaching was determined in neutral normal ammonium acetate (pH 7) extract of soil solution with standard solution of potassium chloride (USDA, 2004). The water quality parameters of leachate were evaluated by Digital water analyzer.

RESULTS & DISCUSSION
The effect of water ponding depths on Soil nutrient losses and nutrient loss impact on water quality parameters were observed for one hour interval to found the rate of nutrient loss (ammonium nitrogen, phosphorus, and potassium) in leachate water and its water quality parameters (EC and PH) for the 5 cm, 10 cm, and 15 cm depth of water ponding.
The observed data presented in Table 3. The graphical representations of nutrient loss rate in percolated water are presented in Figure 1, Figure 2 and Figure 3.
Soil Nutrient Loss and Water Quality Parameters on 5.00 cm Depth of Water Ponding
The ammonia nitrogen losses were observed maximum in first one hour and it will start decreasing in subsequent hours (Figure 1(a)).
It was varied for 14.44 mg/l to 28.22 mg/l in between five hours duration and the total loss of ammonia nitrogen was found to be 528.06 mg in 29.02 lit (i.e. 18.19 mg/l). The phosphorus losses were showed slightly increasing pattern for first few hours thereafter it showed decreasing pattern and varied from 0.725 mg/l to 1.2865 mg/l in five hours duration.
The total average loss of phosphorus was found to be 0.94 mg/l. It can be visualized (i.e. Figure 2(a)) that phosphorus loss increased as time duration increased for first three hours then it decreased. It may be due to less solubility of phosphorus on water. The potassium loss varied as 1.95 mg/l to 3.196 mg/l in five hour duration. The graphical representation (Figure 3(a)) showed that potassium loss increased for first two hours then it was started decreasing in subsequent hours the total loss of potassium was found to be .94 mg/l. The water quality were also observed on percolated water and found that PH varied from 7.72 to 8.19 and found to be positive correlation with time.
EC was also observed and it varied from 1.008 to 1.970 mmhos/cm and it showed the increasing trend first four hours and then decreasing in last few hours

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Table 3: Observed Values of Nutrient Loss and Water Quality Parameters at Different Depth of Water Ponding

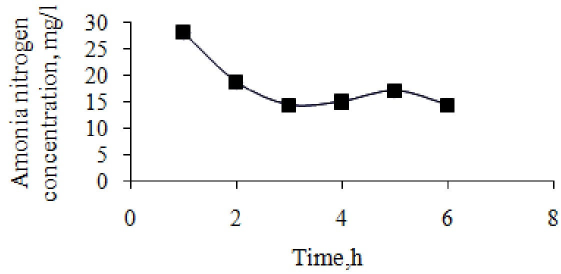
Water Ponding Depth, cm	Time, h	Percolation Rate, ml	Ammonia Nitrogen, mg/l	Phosphorus, mg/l	Potassium mg/l	EC	PH
5.00 cm	1	4700	28.224	0.941	2.975	1.325	7.72
	2	5100	18.816	0.941	3.196	1.584	7.92
	3	6200	14.448	1.287	2.352	1.586	7.85
	4	6100	15.12	0.826	2.213	1.970	8.09
	5	5600	17.136	0.769	1.952	1.359	8.13
	6	1500	14.448	0.725	2.273	1.005	8.19
10.00 cm	1	12050	33.264	1.287	5.004	1.297	7.93
	2	15250	28.56	1.369	3.537	1345	7.98
	3	12200	18.816	1.840	2.755	1.674	8.15
	4	10200	15.12	1.340	2.574	1.598	8.21
	5	5700	20.496	1.116	2.975	1.534	8.19
	6	3500	11.76	0.922	1.953	1.365	8.23
	7	2100	11.088	1.032	1.534	1.17	8.26
15.00 cm	1	15950	35.952	1.430	5.359	1.197	8.19
	2	14850	30.576	1.920	4.014	1.234	8.22
	3	17600	19.152	1.833	3.759	1.594	8.22
	4	12400	14.784	1.603	2.868	1.531	8.16
	5	10500	14.784	1.390	2.132	1.359	8.17
	6	9200	13.44	1.116	2.052	1.289	8.13
	7	6500	15.456	0.972	2.012	1.326	8.13
	8	3700	13.4736	0.892	1.872	1.235	8.15
	9	550	9.8112	0.732	1.451	1.08	8.13

Effect of Soil Nutrient Loss and Water Quality Parameters on 10.00 cm Depth of Water Ponding

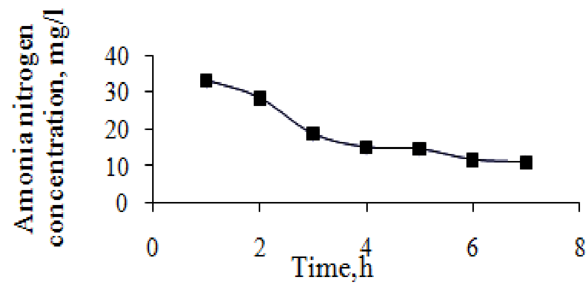
In case of 10 cm water ponding depth, Ammonia nitrogen losses were found in similar trend as discussed for Ammonia nitrogen loss at 5.00 cm/h (Figure (1b)). Ammonia nitrogen was found varied as 11.088 mg/l to 33.26 mg/l. The total loss of ammonia nitrogen was found to be 1401.42 mg in 61 lit of percolated water. The phosphorus loss graphically shown in Figure 2(b) was varied from 0.922 mg/l to 1.848 and the total loss was 84.24 mg in 61 liter. The potassium loss were followed the same patterns as discussed in water ponding depth of 5 cm (Figure 3(b)). The water quality results revealed that PH varied from 7.93 to 8.26. EC values shown a similar pattern as observed in 5 cm depth of ponding.

Effect of Soil Nutrient Loss and Water Quality Parameters on 15.00 cm Depth of Water Ponding

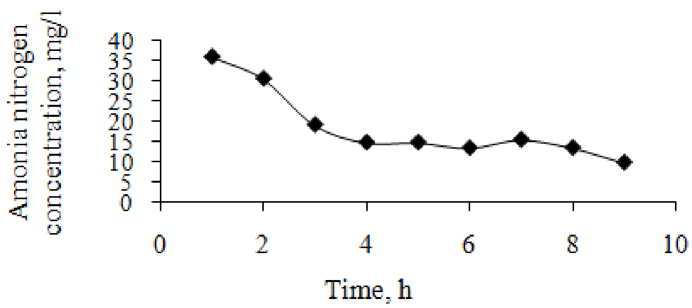
In case of 15 cm ponding depth, the ammonia nitrogen losses were maximum in first one hour and it will start decreasing in subsequent hours as shown in Figure 1(c). It was varied as 9.811 mg/l to 35.95 mg/l from the duration of 9 hours. The total loss of ammonia nitrogen was found to be 1982.17 mg in 91.25lit of percolated water. The phosphorus loss was varied from 1.87 to 2.53 mg/l. and the total losses of phosphorus was found to be 138.34 mg in 91.25 liter. It was observed that phosphorus loss increased for two hours and then decreased as time duration increased. The graphical representation is shown in Figure 2(c). The potassium loss varied as 1.95 to 5.36 mg/l. graphical representation in Figure 3(c) showed that potassium losses were highest for one hour then it was started decreasing in subsequent and the total loss of potassium was found to be 509.98 mg in 91.25 litre of percolated water. The observed PH varied from 8.13 to 8.22 and it increases in first three hours and decreased subsequently in last five hours. The value of EC was varied from 1.080 to 1.594 mmhos/cm. The value of EC showed gradually decreasing pattern.



(a) At 5cm Depth of Water Ponding

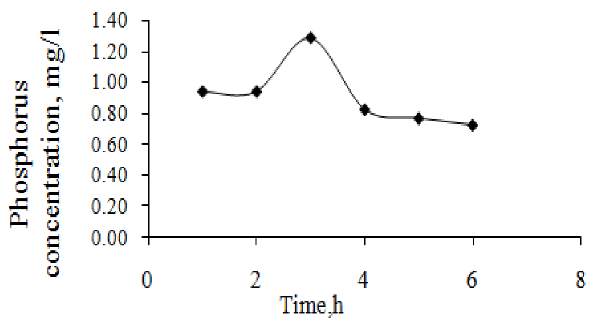


(b) At 10 cm Depth of Water Ponding

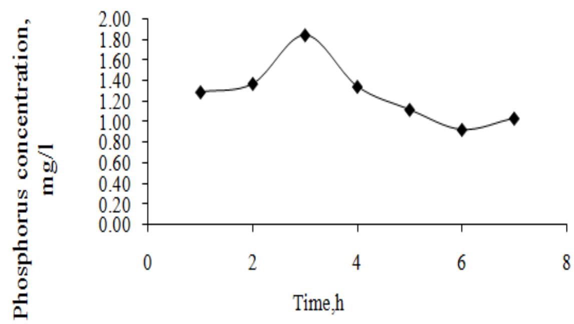


(c) At 15 cm Depth of Water Ponding

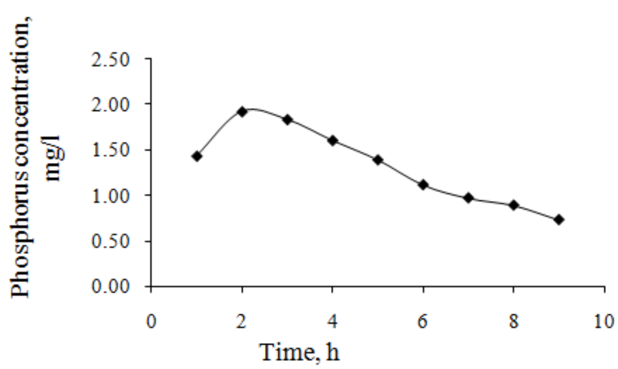
Figure 1: Ammonia Nitrogen Concentration at Different Depths of Water Ponding



(a) At 5 cm Depth of Water Ponding



(b) At 10 cm Depth of Water Ponding



(c) At 15 cm Depth of Water Ponding

Figure 2: Phosphorus Concentration at Different Depths of Water Ponding

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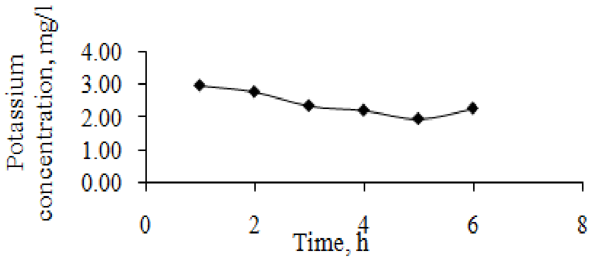
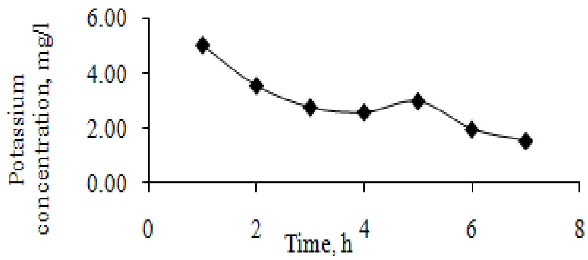
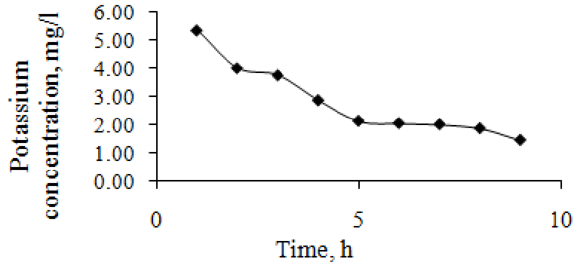


(a) At 5 cm Depth of Water Ponding



(b) At 10 cm Depth of Water Ponding



(c) At 15 cm Depth of Water Ponding

Figure 3: Potassium Concentration at Different Depths of Water Ponding

Conclusion

The study reports the effect of different water ponding depths on major soil nutrient transport (Nitrogen, Phosphorus and Potassium) losses on leachate water and their impact on leachate water quality. The rate of nutrients losses (N, P and K) were found to be increased with increasing water ponding depth and land slopes for all selected treatments. The concentration of ammonia nitrogen and potassium in percolated water was found to have a decreasing trend with time for every depth of water ponding while the concentration of phosphorus was found to be increasing with time for first few hours in leachate and thereafter started decreasing. The values of EC and pH in leachate water were also found to be decreasing with time in each case.

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