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Efficacy of Using Dairy Manure Compost as Erosion Control and Revegetation Material.

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***Abstract*.** In a simulated rainfall study, first flush (one liter) and the remaining runoff samples were collected from 12 non-vegetated and isolated field plots established on a 3:1 embankment constructed as a road right-of-way. These plots were assigned to four treatments namely; compost manufactured topsoil (CMT), 2.5 cm of dairy manure compost (DMC) incorporated into 8-cm of topsoil, erosion control blanket (ECC), a 5-cm layer of DMC and woodchips blended (2.5 cm each mixed by volume) and applied on top of the undisturbed soil, agronomic rate compost (ARC), DMC broadcast at 39.5 t/ha, and commercial fertilizer (CF) broadcast at the rate of 112kg N /ha for, 49 kg P /ha, and 83 kg K /ha, respectively.

The ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff as compared to those in the runoff from CF plots. Overall, plots amended with DMC or DMC/woodchips blend, though much higher in N, P and K, produced less runoff and sediment and nutrients in the runoff as compared to the mineral fertilizer plots without any organic amendment. It was concluded that ECC and CMT treatments established to control erosion and revegetate, respectively, a newly constructed road-right-of-way and shortly there after, subjected to rain (a worst case scenario) will be effective in erosion control. Even though compared to the CF treatment, generally smaller quantities of N, P and K were measured in the runoff from ECC and CMT treatment plots, N and P concentrations in the runoff were high from the standpoint of water quality.

Keywords. Compost, dairy manure, erosion, phosphorus, runoff, sediment, watershed

Introduction

Several watersheds with large and concentrated animal feeding operations (CAFOs) in the USA are faced with a challenge to either reduce manure application rates on agricultural soils that test high in phosphorous (P) or find alternatives to manure utilization by row crops and pastures. The Bosque and Leon River watersheds in central Texas are home to nearly 100,000 lactating dairy cows that reside on 165 farms. Most of these cows are housed either on openlots or hybrid systems of openlots and freestall barns. Manure from openlots is scraped and stock piled while liquid waste (manure, process generated wastewater from flushed freestalls, milking parlors and paved alleyways in openlots, and any runoff water) is stored in waste storage or treatment structures (lagoons). In general, a majority of the dairy manure from these operations is handled as solid manure. Traditionally, solid manure and liquid waste have been spread and irrigated, respectively to waste application fields (WAF) as nutrients for crops and pastures, and to meet the plant water requirements. The North Bosque River (NBR) basin has the highest concentration of dairy cows in the area. Water quality studies in the watershed indicated that P was the limiting nutrient in this basin and dairy WAFs and municipal waste treatment plants were considered major non-point and point sources of P to the NBR, respectively (McFarland and Hauck, 1999a, 1999b). In 1998, segments 1226 and 1255 of the NBR and Upper NBR, respectively were deemed "impaired segments" on the State of Texas Clean Water Act Section 303(d) under water quality standards related to nutrients and aquatic plant growth (TNRCC, 1998).These findings led to the US Environmental Protection Agency's approval for the two Total Maximum Daily Loads (TMDLs) for P in the NBR (TNRCC, 2001). In December 2002, the Texas Commission on Environmental Quality (TCEQ, previously known as the Texas Natural Resource Conservation Commission or TNRCC) approved the implementation plan for the two TMDLs. The goal of these TMDLs was to achieve a reduction of total annual loading and annual average concentrations of soluble reactive P (SRP) by approximately 50%. The Bosque River Advisory Committee, a group of scientists, engineers and other stakeholders, expects that both point and nonpoint sources will have to make significant reductions in their P contributions to achieve this goal.

As a result of poor water quality conditions in the NBR watershed, the TCEQ rules implemented in 1999 required that every new or expanding CAFO in the watershed must remove 100% of the collectible manure produced in the facility. Manure should be disposed of beneficially outside the watershed (landfills), delivered to a composting facility or applied as fertilizer to WAFs that have not received manure previously and have less than 200 ppm of extractible P in the top six inches of soil (TNRCC, 1999). Consequently, a voluntary program called the "Compost Program" was initiated by the TCEQ and the Texas State Soil and Water Conservation Board (TSSWCB) with a goal to remove nearly 50% of the manure generated by the CAFOs in the NBR watershed as an 'efficient way' of dairies to meet these new rules (TCEQ, 2003). In 2000, as part of this program, the TSSWCB launched the Dairy Manure Export Support (DMES) project that provided financial support to haul surplus manure from dairies in the NBR watershed to the TCEQ permitted composting facilities in the NBR watershed. These composting facilities provide dairies an alternative to direct application of manures on soil testing high for P in the watershed. The TCEQ portion of the program strived to create a sustainable market for compost from dairy manure.

Recently published works by Persyn et al. (2004) and Risse and Faucette (2003) cite use of compost from various organic materials including animal manure for erosion control and revegetation of highway construction sites. Compost from cattle feedlot, dairy and poultry manure mixed with woodchips, cotton burs and yard trimmings has been utilized by many state transportation departments for erosion control of road rights-of-way and to establish vegetation on severely eroded soils (Block, 1999, 2000; Mitchell 1997). Departments of transportation from several states have developed compost use specifications (USEPA, 2003) for construction related projects. Texas Department of Transportation (TxDOT) accepts organic composts including dairy manure compost (DMC) for use in compost manufactured top soil (CMT), in erosion control compost (ECC), as general use compost (GUC) and compost in the form of filter berms for erosion and sedimentation control. For the TxDOT contracts, the CMT should consist of 75% topsoil blended with 25% compost on a volume basis and for ECC, 50% untreated woodchips are blended with 50% compost by volume (Special Specifications 1058 for compost and 1059 for compost/mulch filter berm, TxDOT, 2002). The TxDOT specifies the use of ECC to be limited to slopes of 3:1 or flatter allowing an application of a 2" uniform layer of compost and woodchips blend. These specifications provide an opportunity to remove DMC (hence dairy manure) out of the NBR and use it on the TxDOT projects, as an alternative to manure utilization on traditional crop and pasture land in the watershed. Large quantities of DMC will be used as CMT or ECC to vegetate and protect slopes such as the road rights-of-way. Little information is available on physicochemical quality of runoff from these CMT and ECC treated slopes using blends of DMC and woodchips.

The objective of this study was to examine the efficacy of using composted dairy manure for stabilization and revegetation of steep slopes. Results of runoff and its physicochemical constituents from filed plots amended with DMC, DMC/Woodchips blend, and commercial fertilizer (CF) and subjected to simulated rainfall are presented in this paper.

Materials and Methods

Experimental plots and treatment set-up

Twelve plots, each 1x 2m were established on an embankment with 3:1 side slope and constructed to mimic a road right-of-way (Li et al., 2003) at the Riverside campus of the Texas A&M University near College Station. The embankment soil was clayey with an average pH of 8.13 from the 0-15-cm (0-6") depth and devoid of vegetation. Average sand, silt and clay contents from the 0-15 cm depth were 26%, 27%, and 47%, respectively. Each plot was isolated from overland flow using 15-cm (6") metal borders installed 10-cm above and 5-cm below the ground level. At the downstream end of each plot, a parabolic shaped gutter made from a 10-cm PVC pipe, spliced in half longitudinally, was installed to convey plot runoff to plastic buckets. Four treatments namely, erosion control compost {ECC, per TxDOT (2002) specifications}, compost manufactured topsoil {CMT, per TxDOT (2002) specifications}, agronomic rate compost (ARC) and commercial fertilizer (CF) were replicated (blocks) three times and randomly assigned to 12 plots, in a 'randomized block' design (Figure1). For each CMT treatment plot, a 2.5-cm (1") layer of DMC was incorporated in to 8-cm (3") of the topsoil using a heavy duty garden hoe. For each ECC treatment plot, a blend of 50% DMC and 50% woodchips by volume was applied as a 5-cm (2") thick layer of erosion control blanket on top of the existing undisturbed soil. Dairy manure compost at a rate of 39.5 t/ha (16 t/ac) was applied on undisturbed soil of each ARC treatment. Each CF treatment plot received mineral fertilizer at the rate of 112kg/ha (100 lb/ac) for nitrogen (N), 49 kg/ha (44 lb/ac as P or 100 lb/ac as P_2O_5) for phosphorus (P), and 83 kg/ha (83 lb/ac as K or 100 lb/ac as K_2O) potassium (K), respectively. Table 1 shows application rates (kg/ha) of N, P, and K for each treatment.

Rainfall simulation and surface runoff sampling

Two rainfall simulators (Figure 2), similar to those used in the National Phosphorous Research Project (Sharpley and Klienman, 2003) and described by Humphry et al. (2002) were used simultaneously to conduct rainfall simulation and runoff sampling experiments on experimental plots. Each simulator was designed and equipped with one HH-SS50WSQ nozzle (Spraying Systems Co., Wheaton, IL).

Table 1. Nitrogen, P and K application rate (kg/ha) and moisture content at 0-5 cm depth of treatment plots.

Treatment	**N,** kg/ha (lb/ac)	**P,** kg/ha (lb/ac)	**K,** kg/ha (lb/ac)	**Moisture** % (v/v), n=15
CMT	1,635 (1,459)	545 (486)	3,493 (3,116)	21.35 ±4.07*
ECC	2,976 (2,665)	903 (806)	5,985 (5,340)	14.37 ±2.75
ARC	199 (178)	66 (59)	425 (379)	27.44 ±5.18
CF	112 (100)	49 (44)	93 (83)	27.21 ±3.6

*Standard deviation

On each plot, simulated rainfall of 92 mm h^{-1} (3.6” h^{-1}) average intensity (25-yr return frequency of a 1-h storm at the experimental site) from an average height of 3.22 m (10.6 ft) above plot surface was applied to cover a 4-m^2 footprint, which ensured complete coverage of the 1 x2 m plot. Rainfall with this intensity was applied on each plot until 30-min of runoff was obtained.

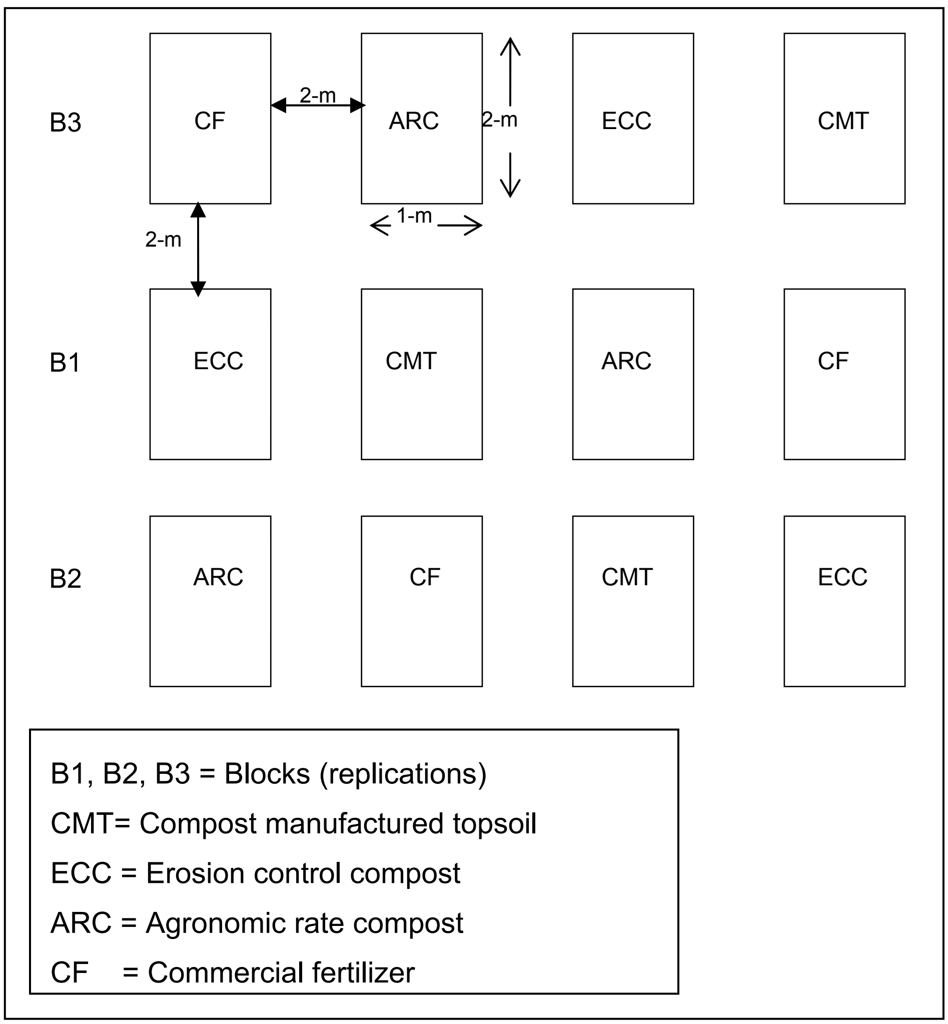

Figure 1. Experimental plots and treatment set-up (dimensions are not to scale)

The simulator frame, a 2.8 m (L) by 2.3 m (W) by 3 m (H) aluminum structure, was fitted with plastic tarps (walls) to minimize wind interference during the rainfall event. Each simulator was leveled on its telescopic legs (pegs) and installed so that the nozzle was centered above the plot. A 1,025-gal capacity water tank and de-ionizing system were used to supply water with a pH of 5.6 and an electrical conductivity of 0.015 µS m^{-1}. Prior to rainfall simulation, volumetric soil moisture was determined at the 0-5-cm (0-2") depth from each treatment plot using a capacitance sensor (Theta Probe, Delta-T Devices, Cambridge, UK) at five locations within a plot (Table 1).

Figure 2. Two rainfall simulators wrapped in plastic tarps, and a nozzle in use at the runoff plots.

After the start of rainfall on a plot, the time to initiate runoff (time difference between start of rainfall and beginning of overland flow) was recorded and the first liter of this runoff (the 'first flush') was collected directly in a plastic bottle. The remaining runoff was conveyed from PVC gutters to a plastic bucket and pumped to 26-L plastic containers. Total mass and volume of 30 min of overland flow from each plot was measured by weighing the containers. After weighing, the contents of all containers were emptied in a 136-L plastic drum, thoroughly agitated to resuspend solids and a representative 'sub sample' was collected in a plastic bottle. The entire procedure for rainfall simulation and runoff sampling was repeated for 12 plots.

Soil, compost, woodchips, and runoff analysis procedure

All soil, compost, compost/woodchips blend and runoff samples were analyzed for various physicochemical properties at the Soil, Water, and Forage Testing Laboratory, Department of Soil and Crop Sciences at the Texas A&M University. Additionally, runoff samples were also analyzed for total solids (TS) and total suspended solids (TSS) at Inter-Mountain Laboratories Inc., in College Station. Three composite soil samples were taken with a hand probe from 0 to 15-cm depths at the experimental site near bordered plots. Each core was divided into 0-5cm and 5-15 cm in depth. The soil samples were analyzed for extractable soil P (Hons et al., 1990) through Inductively Coupled Plasma Optical Emission Spectroscopy (ICP) and NO_3-N was analyzed using a modified version of Keeney and Nelson (1982) where 1M KCL was substituted for 2M KCL.

Three representative samples of dairy manure compost (DMC) and two representative samples of DMC/woodchips blend were also collected. These samples were pulverized to finer than 100 mesh, to decrease heterogeneity and 0.5 g of the pulverized sample was digested as received with sulfuric acid/selenium/lithium sulfate Kjeldahl digest (Parkinson and Allen, 1975). Total Kjeldahl Nitrogen (TKN) was determined colorimetrically using a Technicon Auto Analyzer II

(Technicon Instruments Corporation, Tarrytown, NY). Total elemental P and K were analyzed using ICP.

A portion of ‘first flush’ and ‘rest of the runoff’ samples was filtered through a 0.45-micron pore-diameter filter. The unfiltered samples were blended and digested as received and analyzed for TKN, P and K using the same procedure used for the compost and woodchips samples. The filtered samples were analyzed for total dissolved P DP), dissolved K (DK), Nitrate-nitrogen (NO_3-N) and ammonium –nitrogen (NH_4-N) using ICP.

Total solids and TSS were determined from the unfiltered samples of the first flush and the rest of the runoff using Standard Methods (APHA, 1995) 2540B and 2540D, respectively. For TS, a sample was well mixed and dried to a constant weight at 105 ^{O}C. The dried sample contents represented TS. For the TSS determination, a well-mixed sample was filtered through a glass-fiber filter. The residue retained on the filter was dried to a constant weight at 105 ^{O}C. The dried sample contents represented TSS. For liquid samples, pH was measured directly using a probe and for solid samples it was determined from 2:1 water to solid paste.

Statistical analysis

A complete randomized block design was used to compare treatment effects on various physicochemical parameters in this rainfall-runoff study. Fisher’s least significant difference (LSD) method was used to compare treatment means. The data were analyzed using ANOVA procedure on Stat View software by SAS Inc.

Results and discussion

After initiation of the runoff from a simulated rainfall event, water leaked out of the borders from one experimental plot assigned to the CMT treatment. Therefore, only two replications for this treatment were included in the statistical analysis for all parameters related to runoff sampling and analysis.

Time to initiate runoff

The total time to initiate runoff, total mass of runoff, TSS and TS, and their respective standard deviations for each treatment are plotted in Figure 3. The average time to initiate runoff from the CMT plots was significantly higher ($p \leq 0.05$) than that from all other treatment plots while it was statistically similar among the ECC, ARC and CF treatment plots. The average time to initiate runoff from the ECC plots was the shortest (3.66 min) of all treatments. In fact, as compared to the ECC plots, it took more than twice as much time for the runoff to begin from the CMT (7.7 min) plots.

For the ECC plots, this may have been due to a lack of moisture absorption by the woodchips in the blanket (compost and woodchip mixture) as it was observed that at the beginning of the rainfall, this blanket was somewhat hydrophobic. On the other hand, the tillage induced conditions including reduced soil moisture (Table 1), increased surface roughness and reduced crusting and sealing may have resulted in increased infiltration of the CMT treatment plots, thereby delaying runoff time. Significantly higher initial infiltration from tillage as compared to no-till surface has been observed by Mukhtar et al. (1985).

Total runoff, TS and TSS

The total runoff mass from within each treatment varied highly (Figure 3) and was statistically similar among all treatments. Overall, average total runoff mass from CF was higher than and from ECC was lower than all other treatments.

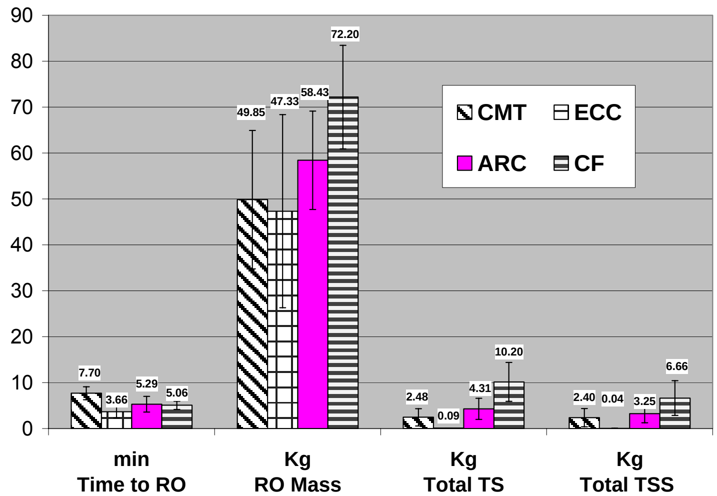

Figure 3. Time to initiate runoff, total mass of runoff and TS and TSS as affected by different treatments.

The CMT plots had the second lowest total runoff mass followed by ARC and CF treatment plots. Although runoff initiated most quickly from the ECC plots, these plots contributed the smallest mass (and volume) of runoff. This in part was due to the fact that ECC plots had the lowest TS and TSS in runoff than those from all other treatment plots (Figure 3). The reduction in TS and TSS (hence erosion) from the ECC plots was due to the reduced raindrop impact. Because the soil surface was covered by the erosion control blanket, this resulted in less detachment and transport of sediment. Additionally, absorption of moisture by dairy manure compost in the ECC and CMT plots may also have contributed to relatively smaller amount of total runoff. Overall, TS amount from the CF treatment plots was significantly higher ($p \leq 0.05$) than that from all other treatments. The TSS amount from the CF plots was significantly higher than that from the ECC plots and higher but statistically similar to that from the rest of the treatments. Lower runoff rates and volumes and reduced soil erosion from organic compost treated soils compared to control treatments have been reported in several studies (Demars et al., 2000, Storey et al., 1996, Risse and Faucette, 2003 and Persyn et al., 2004). Figure 3 also shows that nearly all (2.38kg of 2.46kg) the solids in the runoff from the CMT plots were characterized as suspended solids while TSS amounts in the runoff from all other treatment plots were between 50% and 75% of TS. Additionally, little soil could be detected in the runoff samples from the ECC treatment plots.

Runoff Quality

Table 2 presents physicochemical properties of runoff from the first flush (first liter of runoff collected directly from each plot) and from the subsequent runoff (total remaining runoff) samples. Treatment means and standard deviations of several parameters along with their statistical significance are shown in this table. All values represent total amounts (concentration x total runoff volume) of each parameter in the first flush and the subsequent runoff.

pH

Although the average pH for the rainwater was 5.6, the pH values for the runoff from all treatment plots were neutral or alkaline. This was due to the interaction of rainwater with alkaline soil (pH=8.13) and slightly alkaline compost, and compost/woodchips mix from different treatment plots during simulation runs. The pH for the first flush from the ECC plots was significantly lower than that for the first flush from the CF plots while all other treatments had statistically similar but lower pH values than the CF plots. In the remaining runoff, pH for all treatments increased as compared to the first flush and the remaining runoff from the ECC plots had significantly lower pH than that from all other treatment plots. The highest pH value measured from the remaining runoff was from CF plots. The increase of pH for all treatments in the remaining runoff was due to their higher TS and TSS content as compared to the first flush (Table 2). Also, the first flush and remaining runoff pH being the highest from the CF and the lowest from the ECC plots correspond to the highest TS and TSS in first flush and remaining runoff from the CF and the lowest TS and TSS in first flush and remaining runoff from the ECC plots.

TS and TSS

Total solids and TSS in the first flush from the ECC plots were significantly lower than those in the first flush from the CF plots while all other treatment had lower but statistically similar first flush TS and TSS than those in the first flush from CF plots. A similar trend for these parameters was observed in the remaining runoff from all treatment plots with the exception that the remaining runoff TS from the CF plots was significantly higher than that in remaining runoff from all other treatment plots. The TS and TSS in the first flush and the remaining runoff from all treatment plots followed a trend similar to the total mass of runoff (Figure 3). Table 3 also shows that most of the solids in first flush and remaining runoff from the CMT plots were measured as TSS and overall, plots amended with dairy manure compost or a compost/woodchip blend had lesser soil erosion than the CF treatment plots with no such amendments. This effect is also illustrated in Figure 4 that shows most (CF) to least (ECC) eroded surface conditions post rainfall.

Table 2. Total amounts of physicochemical constituents in runoff from different treatments.

	First Flush				Remaining Runoff			
PARAMETERS	CMT	ECC	ARC	CF	CMT	ECC	ARC	CF
pH	7.15^{ab*} (±0.92)**	7.0^{a} (±0.17)	7.53^{ab} (±0.23)	7.7^{b} (±0.36)	7.95^{a} (±0.21)	7.27^{b} (±0.15)	7.83^{a} (±0.12)	7.97^{a} (±0.12)
TS (Kg)	0.024^{ab} (±0.02)	0.003^{a} (±0.00)	0.032^{ab} (±0.02)	0.06^{b} (±0.04)	2.46^{a} (±1.88)	0.09^{a} (±0.04)	4.28^{a} (±2.29)	10.14^{b} (±4.25)
TSS (Kg)	0.019^{ab} (±0.02)	0.001^{a} (±0.00)	0.024^{ab} (±0.01)	0.04^{b} (±0.02)	2.38^{ab} (±1.98)	0.043^{a} (±0.02)	3.23^{ab} (±1.98)	6.62^{b} (±3.78)
TKN (mg)	13.95^{a} (±11.38)	17.73^{a} (±3.93)	18.6^{a} (±12.49)	54.73^{b} (±26.38)	$1,649^{a}$ (±1,517)	673^{a} (±276)	$1,806^{a}$ (±756)	$5,801^{b}$ (±1947)
NO_3-N (mg)	2.9^{a} (±0.89)	24.7^{a} (±32.2)	29.1^{a} (±5.08)	30.9^{a} (±22.27)	$1,556^{a}$ (±400)	873^{a} (±1,007)	871^{a} (±475)	$1,588^{a}$ (±974)
NH_4-N (mg)	0.4^{a} (±0.4)	2.9^{a} (±4.7)	0.7^{a} (±0.3)	9.4^{a} (±9.8)	205^{a} (±257)	6.7^{a} (±4.69)	16.1^{a} (±12.63)	430^{a} (±404)
P (mg)	3.85^{a} (±3.36)	5.91^{a} (±1.05)	6.4^{a} (±3.03)	17.9^{b} (±8.71)	515^{a} (±317)	258^{a} (±115)	582^{a} (±166)	$1,998^{b}$ (±883)
DP (mg)	0.36^{a} (±0.03)	3.84^{a} (±3.31)	1.83^{a} (±1.33)	6.5^{a} (±6.38)	57.07^{a} (±62.61)	66.26^{a} (±65.59)	69.52^{a} (±74.62)	516.65^{a} (±528.8)
K (mg)	267^{a} (±204)	498.5^{a} (±20.02)	348.2^{a} (±84.37)	476.2^{a} (±177.2)	$24,297^{ab}$ (±12,868)	$16,400^{a}$ (±7,052)	$24,545^{a}$ (±1,478)	$50,883^{b}$ (±16,914)
DK (mg)	4.1^{a} (±2.16)	75.6^{a} (±119.79)	120.5^{a} (±106.39)	68.9^{a} (±102.13)	560^{a} (±419)	$2,152^{a}$ (±3,275)	$2,437^{a}$ (±3,519)	465^{a} (±72)

* Averages in rows followed by different letters are different at 5% level. **Standard deviation

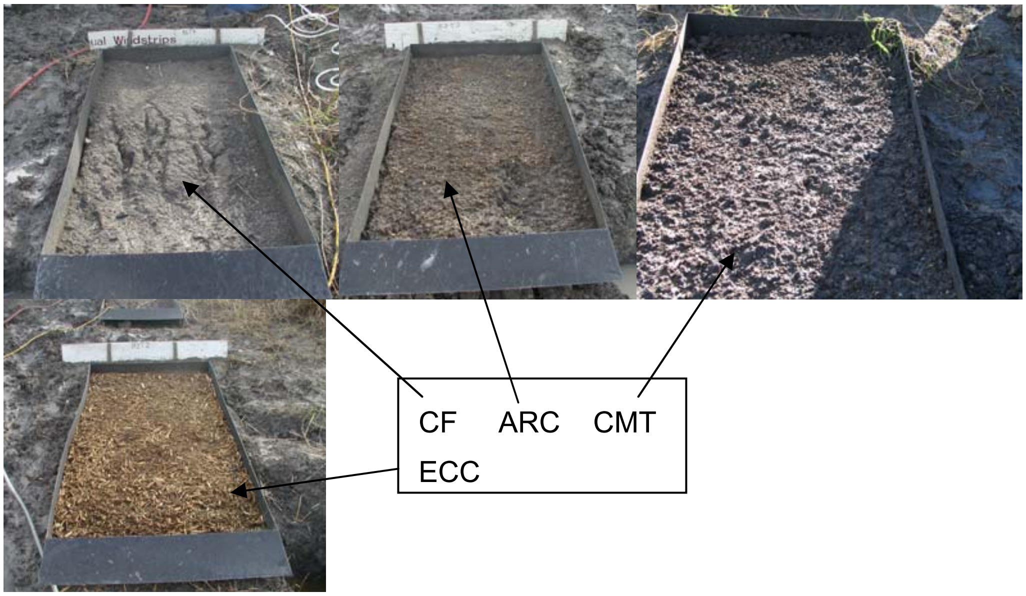

Figure 4. Post-rainfall plot surface conditions of each treatment.

Nitrogen, P and K

As mentioned earlier, all forms of N, P and K in Table 2 are total quantities determined from either the first flush (1-L) or remaining runoff from different treatment plots. As shown in Table 1, the highest rate of N, P and K was applied to the ECC plots followed by the CMT, ARC and CF plots. The TKN in the first flush and remaining runoff from the CF plots was significantly greater than that in the first flush and remaining runoff from all other treatments. The TKN in both forms of runoff from all other treatments was statistically similar. Despite much larger nitrogen applications to the ECC and CMT plots compared to the CAR and CF plots, the TKN, NO_3-N and NH_4-N in runoff from the ECC and CMT treatment plots were always lower than those in the runoff from the CF plots. This is attributed to the significantly higher solids and higher runoff mass from the CF treatment plots. Though highly variable within treatments and statistically similar among treatments, NO_3-N and NH_4-N in the first flush and the remaining runoff from the CF treatment plots were generally higher than those in the runoff from all other treatment plots. If NO_3-N in the first flush (1-L volume) and the remaining runoff from all treatment plots were converted to mg/l (total NO_3-N, mg divided by the remaining runoff mass, L), then with the exception of the first flush from the CMT plots, NO_3-N in runoff from all treatments will be above the 10 mg/l limits for the drinking water quality standards set by the US Environmental Protection Agency (EPA, 1994).

Total P in both forms of runoff from the CF treatment plots was significantly greater than that in runoff from all other treatment plots. The dissolved fraction of P (DP) was highly variable within treatments and statistically similar for either form of runoff from all treatment plots. Generally, DP in runoff was higher from the CF plots than all other treatment plots. As discussed above for the NO_3-N, if total P in either form of runoff were converted to mg/l, it will range from 3.86 $\pm$3.36 mg/l in the first flush from the CMT plots to 27.02 $\pm$8.4 mg/l in the remaining runoff from the CF plots. These concentrations of total P, if introduced to receiving waters of lakes, streams and reservoirs will be much greater than the total P concentration of 100 µg/L, the upper limit of acceptable P to avoid eutrophication of such water bodies (Correll, 1998).

Total and dissolved K in the first flush and the remaining runoff were highly variable within each treatment and statistically similar for K in the first flush and DK in both forms of runoff from all treatments. Total K in the remaining runoff from CF plots was significantly higher than that in the runoff from the ECC and ARC treatments and higher but statistically similar from K in the runoff from the CMT plots.

Conclusion

Despite the shortest time to initiate runoff, the ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff (first flush and the remaining) as compared to those in the runoff from CF plots. In the remaining runoff, TS from the CMT and ARC plots and TS and TSS from the CMT plots were also significantly lower than those from the CF plots. Overall, plots amended with DMC or DMC/woodchips blend produced less runoff and sediment in the runoff as compared to the mineral fertilizer plots without any organic amendment. All plots amended with organic materials received greater amounts of N, P and K as compared to the mineral fertilizer plots. Application rates for N, P and K for the ECC and CMT plots were generally one to two folds higher than those for the CF plots. Despite these very high application rates, TKN in runoff (first flush and the remaining) from the ECC, CMT and ARC plots was significantly lower than that in runoff from the CF plots. Also, statistically similar but lower NO_3-N and NH_4-N were measured in runoff from these treatment plots than those in the runoff from the CF plots. Total P in the CF plots' runoff was significantly higher and DP in runoff from the same plots was higher than but statistically similar to that in the runoff from all other treatments. Significantly higher K in the remaining runoff from the CF plots compared to that in the remaining runoff from the ECC and ARC plots was measured. Dissolved K in the first flush and the remaining runoff was statistically similar for all treatments but generally higher for ARC and ECC as compared to CMT and CF.

The ECC plots had smaller total runoff mass than all other treatments and significantly lower TS and TSS in the runoff as compared to those in the runoff from CF plots. Overall, plots amended with DMC or DMC/woodchips blend, though much higher in N, P and K, produced smaller runoff, and lesser sediment and nutrients in the runoff, as compared to the mineral fertilizer plots without any organic amendment. It was concluded that the ECC and CMT treatments established to control erosion and revegetate, respectively, a newly constructed road-right-of-way and shortly there after, subjected to rain (a worst case scenario) will be effective in erosion control. Although compared to the CF treatment, generally smaller quantities of N, P and K concentrations were measured in the runoff from the ECC and CMT treatment plots, N and P concentrations in the runoff were high from the standpoint of water quality.

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