Article 77

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Performance of a Dry Extended Pond in North Carolina

A dry extended detention (ED) pond relies on settling as the primary mechanism to remove pollutants from stormwater runoff. A dry ED pond is normally empty during dry weather, but rapidly fills up with runoff during a storm event. The stored runoff is gradually released over a period of one to three days, allowing an opportunity for pollutants to settle out to the floor of the pond. Settling can be a very important pollutant removal mechanism, but it does have its limits. Earlier performance monitoring indicated that dry ED ponds had low to moderate ability to remove most stormwater pollutants (see article 64). This conclusion, however, is considered provisional, as many of the dry ED ponds that were monitored failed to achieve their target extended detention times due to design problems. A recent study by Stanley (1994) sheds new light on the potential performance of well-designed dry ED ponds.

Stanley and his colleagues monitored a demonstration dry ED pond in a small coastal plain watershed in North Carolina, and also conducted experiments to explore the settling behavior of stormwater pollutants. The dry ED pond served a 200 acre watershed, composed of a mix of single family, multifamily and commercial land uses (total imperviousness= 29%). Located near Greenville, NC, the watershed had the sandy soils and low relief characteristic of the coastal plain.

The dry ED pond was designed to provide a maximum of 72 hours of detention for the first half-inch of runoff through the use of a vertical perforated pipe at the pond's outlet. Any runoff in excess of the half-inch was bypassed through a concrete spillway, and was not treated. The pond ranged in depth from eight to 11 feet deep when full, but was designed to fully drain after a storm event. Like many other "dry" ED ponds, the 1.75 acre grass bottom of the pond has gradually become more soggy since it was constructed in 1991, and some portions near the outlet are reverting to a shallow wetland.

The pond's performance was monitored during eight storm events in 1992, that ranged from about a half-inch to two inches of rainfall. One storm, however, was a real whopper. This storm dropped a total of 9.28 inches of rain over a period just less than five days. As a consequence, about 70% of the total runoff volume bypassed the pond through the spillway during this rare storm and was not treated. Thus, Stanley's sampling effort provides a glimpse of how well ED ponds perform during extremely large and rare storm events.

The overall results of the performance monitoring were generally consistent with prior studies (Table 1). Removal of particulate pollutant that are prone to settling was moderate to high, and removal of predominantly soluble pollutants (not subject to gravity) was low or negligible. This behavior was particularly evident when nitrogen and phosphorus was considered. Removal of the particulate fraction of nutrients was moderate (33 to 43%) while removal of soluble nutrient fractions was poor (+ 10% to -9%). Consequently, the combined removal rate for total phosphorus and nitrogen was a modest 14% and 24%, respectively. Removal rates for trace metals predominantly found in

Table 1: Median Pollutant Removal Rate Observed in the Greenville Dry ED Pond (N=8)

Water Quality Parameter	All Storm (%)	Big Storm* (%)
Total Suspended Solids	71	25
Particulate Organic Carbon	45	19
Particulate Nitrogen	43	22
Particulate Phosphorus	33	17
Cadmium	54	12
Chromium	49	16
Copper	26	11
Lead	55	19
Nickel	43	27
Zinc	26	11
Ammonia (NH_4-N)	9	20
Nitrate-N	(-2)	6
Total Dissolved Phosphorus	(-9)	6
Dissolved Organic Carbon	(-6)	(-5)
Total Phosphorus	14	—
Total Nitrogen	26	—

* Removal Rate includes pollutants that bypassed the pond through the emergency spillway and were not subject to settling

Table 2: Pollutants Settled After 72 Hours, Average of Three Trials *(Stanley, 1994)*

Water Quality Parameter	Percent Settled
Total Suspended Solids	93
Lead	77
Cadmium	73
Chromium	72
Nickel	66
Total Nitrogen	50
Total Phosphorus	46
Copper	45
Zinc	35
Total Organic Carbon	35
Dissolved Organic Carbon	23

particulate forms ranged from 40 to 50% (cadmium, chromium, nickel and lead) whereas removal rates for metals that are partially in soluble form (such as copper and zinc) were only half as great. Limited sampling fecal coliform indicated that bacteria levels were slightly reduced as they passed through the dry ED pond.

Table 1 also shows the pollutant removal that occurred in the pond during the rare 9.28 inch rainfall event. Stanley calculated the removal rate based on the total inflow and outflow from the pond, which includes about two thirds of the total runoff volume that bypassed the pond and was not subject to settling. As might be expected, removal rates sharply declined during the storm. Still, removal rates remained positive, which is surprising given that only one-third of the runoff volume was ever subject to extended detention. This suggests that the ED pond was still capable of providing good removal for the first half inch of runoff, even during a storm that delivered six times more runoff volume (three inches) than was designed to be treated.

The results of three settling column experiments were generally consistent with prior research on pollutant settling in urban runoff, as well as the performance monitoring results (Table 2). Moderate to high removal was observed for particulate pollutants after 72 hours, such as suspended sediment, particulate forms of carbon and nutrients, and several trace metals. In most cases, the bulk of the settling occurred in the first 6 to 12 hours of the settling experiments.

Only minor increments of additional settling occurred in the second or third day. Pollutants that are present partly or mostly in soluble forms, such as orthophosphorus, copper and zinc, did not settle out, even after 72 hours of settling. A comparison of the settling column data with actual pond performance data reveals that removal rates were consistently 20 to 30% higher under the ideal settling conditions of the column experiments. This would seem to suggest that more turbulent conditions in the pond reduced settling rates.

Stanley's study provides further evidence as to the benefits and limitations of dry extended detention. Clearly, such ponds are capable of effectively removing particulate pollutants, but have little or no capability to remove soluble pollutants that often have the most influence on downstream aquatic ecosystems. Pond systems that utilize other pollutant removal mechanisms, such as wet ponds and stormwater wetlands still offer more reliable removal for these pollutants.

—TRS

Reference

Stanley, D. 1994. *An Evaluation of the Pollutant Removal of a Demonstration Urban Stormwater Detention Pond*. Albermarle-Pamlico Estuarine Study. Report 94-07. 112 pp.