PASSIVE POLYMER APPLICATION FOR TURBIDITY REDUCTION

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ABSTRACT. Erosion of soils due to urban development, timber harvesting, and agricultural practices is a significant issue and topic of concern on a global scale. Large construction projects are highly vulnerable to sediment removal by erosive forces. Construction sites introduce sediment loads, on a per acre basis, into surrounding waterbodies 2000 times more than forested lands and 10 to 20 times more than agricultural lands (EPA, 2000; Owen, 1975). Elevated levels of suspended sediment introduced into surrounding water bodies from urban construction can result in both environmental and economic impacts (Clark, 1985).

Excess sediment from construction activities has a variety of negative impacts on surrounding receiving water bodies including; river bed scour, reduced water clarity, and transport of chemicals and nutrients. Increased sediment input into drinking water reservoirs creates high turbidities that interfere with chlorination treatment and increase treatment costs (AWWA, 1990; LeChevallier et al., 1981). Comprehensive financial impacts due to soil erosion from all causes have been estimated at $400 billion worldwide (Pimentel et al., 1995).

Turbidity, resulting from excess sediment, has gained recognition as an indicator of pollution in surface runoff from construction activities. Turbidity specific impacts include the reduction of light penetration into water limiting productivity for photosynthetic organisms (Kirk, 1994) and reduced visual range for organisms requiring sight (Vogel and Beauchamp, 1999). Turbidity and suspended sediment are transported via both point and nonpoint sources. From a regulatory standpoint, construction sites are considered point sources; whereas turbidity and sediment discharged from forestry practices and agricultural lands are considered nonpoint sources. South Carolina has established a water quality standard for turbidity in which waters with more than 25 percent of samples greater than 50 NTU, collected over a five year period, are considered impaired waterbodies and listed for turbidity on South Carolina's 303(d) list (SCDHEC, 2004). Of the 1106 impaired waterbodies on the 2010 303d list, 53 are impaired by turbidity (SCDHEC, 2010).

Research has shown that common structural sediment retention devices may be unable to reduce turbidity below the proposed EPA 280 NTU effluent limit under certain circumstances (Line and White, 2001; Haan et al., 1994; Wu et al., 1996). Although trapping efficiency can be relatively high, research suggests that conventional sediment control structures on construction sites are not sufficient to reduce elevated turbidity levels to desired levels.

The Environmental Protection Agency (EPA) is currently moving towards regulations that would establish a nationwide maximum turbidity effluent limit discharged from construction sites. Turbidity effluent guidelines were also selected based on the ability to easily measure and achieve instantaneous results. Additionally, high turbidity in waterbodies is generally what is first noticed by the public and is not thought of as being aesthetically pleasing. Currently, EPA is currently revising the 280 NTU numeric effluent limitation that was first developed in 2009 (EPA, 2010).

North Carolina is currently promoting and regulating the use of chemical flocculants, such as PAM, for erosion and sediment control on active construction sites, specifically to aid in removal turbidity caused by fine suspended sediment. Polyacrylamide (PAM) is a water-soluble synthetic polymer that has long been used in water treatment applications to induce flocculation. In general, flocculants cause aggregation of fine particles suspended in liquid to form flocs or larger particles, which more readily settle out of suspension (Ives, 77). For erosion control and environmental applications, anionic PAM is more widely used due to its low aquatic toxicity (Sojka et al., 2007).

Current research shows PAM application when combined with BMPs in construction site runoff can be essential in achieving turbidity limits within state and federal effluent limits. PAM application to several types of ditch checks reduced turbidity by 61-93% when compared to untreated ditch checks (McLaughlin and McCaled, 2010). Temporary erosion control devices, such as sediment tubes, are more widely used on linear projects where sediment basins are not applicable. Additionally, these devices are less expensive than other channel BMPs and require less man-power for installation.

The focus of this research is to maximize turbidity and total suspended solids (TSS) reduction using passive polyacrylamide (PAM) applications in conjunction with excelsior sediment tube deployment. To simulate construction site runoff, a 185-ft triangular channel, 12-ft wide with an average depth of 1.65-ft, at a 7% slope was constructed and lined with a 50-mil HDPE liner. A 4,800 gallon collapsible tank with a peak flow rate of 1.91 cfs and an average flow rate of 0.72 cfs over 12 minutes, was used to achieve a homogenous sediment-laden water solution. Four different treatments were derived to evaluate different PAM applications, including a control where sediment tubes were evaluated alone.

Figure 1. Experimental Setup

Results indicate that under experimental test conditions, sediment tubes without PAM application provided no observed reduction in turbidity (Fig. 2) or TSS (Fig. 3).

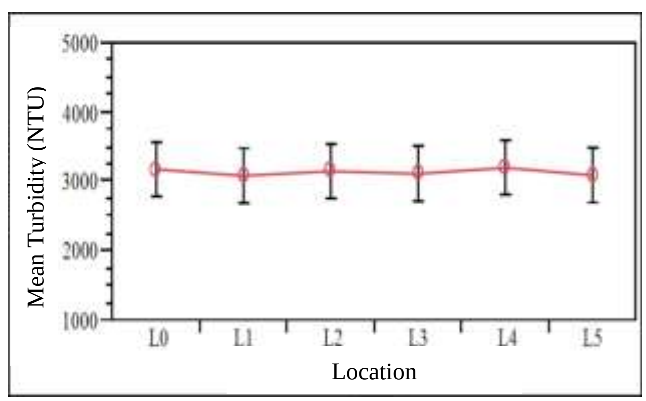

Figure 2. Mean turbidity across sample locations

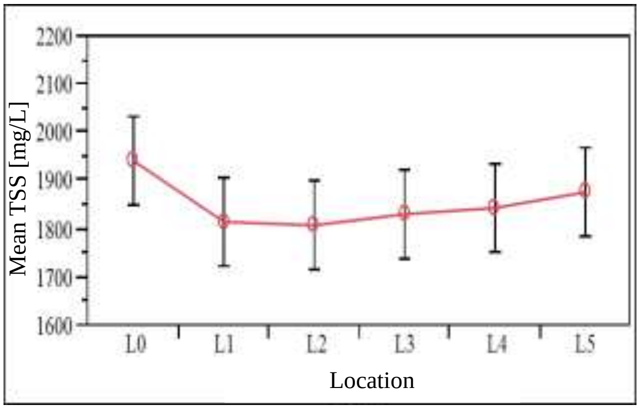

Figure 3. Mean TSS across sample locations

Statistical analysis using JMP statistics software (SAS Institute Inc., Cary, NC, USA) was utilized. Mean turbidity across sample locations was not significantly different (F-stat=0.058, $p=0.99$, $n=60$). TSS reduction across sample positions was found to be not significantly different (F-stat = 1.2802, $p = 0.3112$, $n = 30$). Based on these results, it is possible to conclude that under the described test conditions sediment tubes alone provided no reduction in turbidity and TSS.

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