Improving Stormwater Treatment Efficiency Based on Runoff Properties at Mammoth Cave National Park.

Hung-Wai Ho*[1], and Rick Toomey[2],
_Acknowledgement: Thomas Byl[1,3]

[1]College of Agriculture and Environmental Science, Tennessee State University,
3500 John A Merritt Blvd, Nashville, TN 37209
[2]Science and Resources Management, Mammoth Cave National Park, KY 42259
[3]U.S. Geological Survey, 640 Grassmere Park, Suite 100, Nashville, TN 37211

Mammoth Cave National Park is the home of the longest cave and one of the most biologically diverse cave species and biotic cave communities in the world. With more than half a million visitors are attracted annually, anthropogenic contaminants from human activities,and vehicle traffic and development can be carried by storm runoff into groundwater and into the cave. , and Contaminants in the storm runoff can threaten the aquatic habitat of rare and endangered species. The objectives of this research waeres to determine the amount and sources of major pollutants, analyze the treatment efficiency of the current stormwater treatment system, and provide improvement solutions to increase the stormwater treatment efficiency.

In this research, preliminary sampling was performed to get a betterrief understanding of the storm runoff. Natural and simulated storm samples were collected and analyzed with grab sampling. YSI datasondes equipped with specific conductivity and turbidity probes was also used to optimize the sampling strategy. The result from preliminary sampling indicated that most of the dissolved constituents and suspended solids were accumulated during the dry period and carried into the drainage system during the first-flush of storms. Based on this observation, passive first-flush samplers were designed, constructed and installed at the storm drain inlets. Concentration of pollutants collected from the samplers between 2011 and 2013 were used in regression analysis to determine the correlations between pollutants from storm runoff and the surrounding environment of different locations. Range of concentration of three major pollutants determined from first-flush samples are as follows.: Zzinc concentrations ranged from 0.0 to 0.72 mg/L and copper concentrations ranged from 0.9 to 31.4 mg/L. Zinc and copper are commonly found in vehicle tires, brakes pads, aged rood, and drainage pipes. These two pollutants are also abundant in the nature, but they are toxic at high concentrations. Quaternary ammonia compound (QAC) concentration rangeds from 0.071 to 0.206 mg/L, and it is can be found int detergentcleaners, sanitizer, Lysol®,WNS biosecurity stations (2011-13) and disinfectants in RV recreational vehicle sewage tanks.

Data compiled from several sites and storm events were used to run regression correlations based on the length of dry period between precipitation eventss and, the basin size and contaminants. A strong correlation was found between the length of dry periods and the increase in specific conductivity, as well as, and the concentration of copper. It should be noted that tThe correlation does not imply cause and effect. However, it is reasonable to assume long dry periods allow greater accumulation of potential dissolved solids such asand heavy metals from the parking lot runoff. The amount of zinc and QAC in the first-flush samples and the basin sizes also showed a strong correlation in which both the amount of zinc and QAC increased with the increase in basin size. This correlation can be explained by the land- use distribution of the targeted basins that are consisted of mainly parking lots and developmentwalkways. The increase in human and vehicle traffic and on the development impervious surfaces increased the potential and the amount of contaminants to be carried by storm runoff.

Currently, a stormwater filter system is used for treatment of storm runoff at Mammoth cave National Park. The system was designed in 2003. The main treatment mechanisms of the system involve filtration and adsorption of pollutants with filter materials or adsorbents in the filter cartridges, and filtration of debris by hydrodynamic separators. The suggested lifespan of the treatment system before maintenance by the manufacturer is about 2 years. This research studied the treatment efficacy of the adsorbents, ZPG® and determined the lifespan of the treatment system based on local conditions. The filter material, ZPG®, consists of Zeolite, Perlite, Granular Activated Carbon (GAC), and is collected from the Stormwater Management StormFilter® for this study. Each sorbent has its specific treatment strengths, and a combination of media can constitutes a more effective configuration than single media, and to meet a wide range of treatment goals.

BThe batch method was used in the experiment to determine the adsorption isotherms, rate and capacity of ZPG®. Adsorption of Cu(II) and Zn(II) were found to fit the Langmuir Adsorption model which indicates that the adsorption of Cu(II) and Zn(II) are by filtration with the micro-sized pores in ZPG™ and cationic exchange with the metal ions on the surface of ZPG.™ The adsorption of Cu(II) and Zn(II) were found to have rapid initial rate and became stable within 24 hrs which indicated that the adsorption rates decrease with time. These results can be explained by the competitive effects between metal ions in the solution. Once the adsorption site is occupied, it will not be available for further adsorption. For QAC adsorption, it wais found to fit the Freundlich Adsorption model which indicates that the adsorption process is mainly by filtration and intermolecular attraction forces between QAC and ZPG™. Multilayers of QAC form on ZPG™ which agreed with the experimental results that percentage of QAC removal increases with the increase in initial QAC concentration. The increase in amount of QAC bound onto ZPG™ increase the available improves the surface area for adsorption. Adsorption capacity of Cu(II), Zn(II) and QAC was found to be 8.83×10^{-3} mg/g, 0.256 mg/g, and 8.93×10^{-2} mg/g respectively. With the annual loads estimated from the runoff studieswith the capacities, 2 year precipitation intensity and average pollutants concentrations found from field water samples, the lifespan of ZPG™ was estimated to be at least 2.82 years based on the performance of Zn(II) adsorbed onto ZPG™.

The result from the filter material tests indicated that the efficacy of the filter systems decreased with time. The decrease in efficacy also followed withmay be due to leaves clogging of the filter flowpath. Furthermore, organic some pollutants can be washed off by strong intense flush events because of the weak intermolecular force. Problems also found at the hydrodynamic separators in which large amount of leaves andplant debris detritus were accumulated which caused clogging of drainage pipes every deciduous seasonimpaired flow, especially in the fall. Because of the short lifespan and high maintenance cost and frequency, an alternative treatment solution should be considered for future stormwater systems. EPA indicates that biorRetention pondsarea is an ideal stormwater management BMP for parking lotsin conjunction with storm filters may provide the better service and increased life spans. Bioretention areas utilizes soils, and both woody and herbaceous plants to remove pollutants from storm runoff by sedimentation, soil adsorption, natural degradation, and plant adsorption. The removal effectiveness of different pollutants with this method are found to be 43-97% for copper, 64-95% for zinc, 52-67% for total kjeldahl nitrogen, and 92% for ammonium. Bioretention utilizes the natural area to treat stormwater, which saves construction, filter material, and maintenance costs. The approximate construction cost suggested by EPA is about $6500 for each bioretention area.

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