Assessing Water Quality Impacts of Stormwater Runoff[1]

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Abstract

Current "water quality" monitoring of non-point source runoff typically involves periodically measuring a laundry list of chemicals in the runoff waters. This approach, while satisfying regulatory requirements, provides little to no useful information on the impact of the chemicals in the runoff on the real water quality - designated beneficial uses of the receiving waters for the runoff. There is need to focus water quality monitoring on investigating the receiving waters in order to assess whether the chemicals in the runoff are adversely affecting beneficial uses. This paper presents an evaluation monitoring approach for monitoring receiving waters that determines whether the runoff is a significant cause of water quality - use impairments. For each type of use impairment, such as aquatic life toxicity, excessive bioaccumulation of hazardous chemicals, excessive fertilization, etc., highly focused site-specific studies are conducted to determine the use impairment that is likely occurring due to a stormwater runoff event(s) and the specific cause of this impairment.

Key words: stormwater, water quality, monitoring, highway

Introduction

There is growing recognition that domestic and industrial wastewater and stormwater runoff "water quality" monitoring involving the measurement of a suite of chemical "pollutant" parameters in discharge/runoff waters is largely a waste of money. For stormwater runoff, such programs generate more data of the type that have been available since the 1960's on the chemical characteristics of urban area, highway and street runoff. It has been known since that time that runoff from these areas contains a variety of regulated chemical constituents and waterborne pathogenic organism indicators that exceed water quality standards at the point of runoff discharge to the receiving waters. However, discharge monitoring provides little to no useful information on the impacts of the apparently excessive regulated chemicals and unregulated chemicals in the discharge on receiving water water quality - designated use impairment. As discussed by Lee and Jones (1991) and Lee and Jones-Lee (1994a, 1995a,b), many of the chemical constituents in urban stormwater runoff are in particulate, non-toxic, non-available forms. Further, the short-term episodic nature of stormwater runoff events means that significant exceedance of US EPA water quality criteria and state standards based on these criteria can occur in the receiving waters for

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the runoff without adversely impacting receiving water beneficial uses. These issues have recently been reviewed by Lee and Jones-Lee (1995c,d).

The failure of the US EPA and the states to properly assess real water quality use impairment associated with stormwater runoff from urban areas and highways has resulted in highly unreliable reporting of water quality problems in the nation's waters due to urban stormwater runoff (Lee and Jones-Lee, 1994b). Further discussion of the significant over-regulation that is occurring today in implementing water quality standards into permit discharge loads is provided by Lee and Jones-Lee (1995a,e).

In 1994, the Engineering Foundation held a Stormwater Quality Monitoring Conference to discuss current problems with conducting technically valid, cost-effective monitoring of urban stormwater runoff water quality. There was general consensus at that conference that a significantly different approach needs to be taken in monitoring stormwater runoff events from urban areas, highways, streets and industrial areas (Torno, 1994). While not addressed at that conference, the same situation applies to runoff from agricultural and rural lands. Additional information on why there is need for a different approach for assessing the water quality impacts of stormwater runoff as well as developing management approaches for chemical constituents in this runoff is provided in the Stormwater Runoff and Receiving Systems: Impact, Monitoring, and Assessment conference proceedings (Herricks, 1995).

The basic problem is that so little is known about the real adverse impacts of urban area and highway/street runoff that it is not possible to develop an appropriate runoff water quality monitoring program based on the measurement of water quality characteristics at the point of discharge of the runoff into the receiving waters. In order to develop a program of this type, it is essential that a well-defined, site-specific understanding of the relationship between concentrations of constituents measured in the runoff waters and the site-specific water quality impacts that these constituents have on the designated beneficial uses of the receiving waters for the runoff be developed.

Technically valid, cost-effective stormwater runoff monitoring programs should focus on monitoring those constituents in the runoff that cause significant water quality use impairments in the receiving waters for the runoff. The first step to developing a technically valid stormwater runoff water quality monitoring program is the evaluation of the water quality impacts caused by the constituents in the runoff that adversely impact receiving water quality. Monitoring programs that fail to focus on water quality problem issues fail to provide the information needed to effectively manage stormwater runoff quality.

In an effort to address the problems with current stormwater runoff water quality monitoring programs, the authors have developed what they term "evaluation monitoring." Evaluation monitoring focuses on highly selective, site-specific evaluation of the potential for chemical constituents and pathogenic organisms in the runoff waters to cause site-specific use impairments of the receiving waters for the runoff.

Principles of Evaluation Monitoring

The basic approach used in evaluation monitoring of stormwater runoff impacts is the determination of whether the chemical and other constituents in the runoff waters, either alone or in combination with other constituents in the receiving waters for the runoff, cause a significant adverse impact on the designated beneficial uses of these waters to require constituent control, including possibly treatment of chemical constituents in the runoff waters, to eliminate the impact. The initial focus of evaluation monitoring is not the traditional approach of measuring the concentrations of specific constituents in the runoff waters but is water quality - use impairment. For example, a number of the chemical constituents in highway/street and urban area runoff waters are of concern because of their potential toxicity to aquatic life in the receiving waters which could significantly alter the numbers, types and characteristics of desirable forms of aquatic life in these waters. In evaluation monitoring, rather than trying to estimate toxicity from chemical constituent concentrations, toxicity of the receiving waters is measured directly. Toxic effects of concern include acute and chronic toxicity which is manifested in death, impaired growth and impaired reproduction.

In addition to the classical toxic effects associated with chemical constituent impacts on aquatic life, there is also concern about chemicals and pathogenic organisms that cause adverse impacts on aquatic life through the growth of tumors, organ disfunction - lesions, etc. While the classical toxic effects of heavy metals, etc. are usually manifested in a few days to a few weeks during sensitive life stages of the organism, the carcinogenic, teratogenic and mutagenic impacts on aquatic organisms typically take longer periods of time to develop.

Another potential water quality problem associated with highway/street and urban area runoff is the potential for chemical constituents in this runoff to accumulate within edible organism tissue to sufficient concentrations to be a health hazard to those who consume the organisms as food, i.e. cause the organisms to receive a human health advisory. Also of concern is the accumulation of chemical constituents in aquatic life to a sufficient extent to be adverse to higher trophic level organisms such as fish-eating birds and other wildlife.

Other water quality problems of concern associated with stormwater runoff include excessive fertilization of the receiving waters for the runoff which impairs the use of the waterbody for recreation and domestic water supply purposes. Also of concern is the presence of waterborne pathogenic organisms that can impact the sanitary quality of the receiving waters through impaired contact recreation (beach closings) and shellfish harvesting. Further, litter in highway/street and urban area runoff can impair recreational use of receiving waters. Page limitations on this paper preclude the presentation of detailed discussions of approaches for implementing evaluation monitoring.

The authors have developed an application of this approach for the development of the Eastern Transportation Corridor (ETC) which is a new toll road that is currently under construction located in Orange County, California. This approach is being used to develop technically valid, cost-effective stormwater runoff BMP's for this highway.

Evaluation Monitoring vs. Mechanical Monitoring of Receiving Waters

The traditional approach frequently used in ambient water water quality studies is to develop a sampling program where certain physical, chemical and biological parameters are mechanically sampled and analyzed for an arbitrarily developed period of time, usually one year. At the end of this time, attempts are made to try to discern from the data collected water quality impacts of certain discharges - runoff to the waterbody. Often studies of this type yield inconclusive results as a result of there being an insufficient number of samples taken and insufficient number of analyses made of the key parameters at appropriate times to reflect true water quality impacts of the runoff.

Lee and Jones (1983) have discussed the importance of not following the traditional approach of passively examining the data collected in the water quality monitoring program after collection for information on water quality impacts. This "passive" approach toward data review, while easily administered and carried out, frequently fails to provide key information on impacts during critical periods of the year at times when the primary water quality impacts occur. They recommend that "active" water quality monitoring programs be conducted where data analysis proceeds at the time of data collection in which the results of the recent sampling and analyses are used to determine the adjustments in the study program that need to be made as the study program is being carried out to utilize the funds available for the study in the most cost-effective, technically valid manner. The adoption of the evaluation monitoring approach described herein focuses the resources available on defining major real water quality impacts during the time and under the conditions where and when the impacts are most likely to occur.

Conclusions

It is now widely recognized that the monitoring of stormwater runoff from highway/street, urban areas, industrial properties and rural areas involving measurement of a concentration of a few chemical parameters in a few runoff events each year is largely a waste of money. There is general agreement that there is need to shift the monitoring to evaluation of impacts of stormwater runoff in the receiving waters for the runoff. The focus of the monitoring program should be devoted to biological effects-based parameters, such as aquatic life toxicity and bioaccumulation, and water quality - use impairment, such as closure of beaches and shellfish harvesting due to excessive coliform concentrations, etc. The monitoring of specific chemical constituents in the

receiving water's water column and sediments should only be undertaken if the effects-based parameters, such as toxicity, show that the receiving waters for the stormwater runoff are experiencing significant impairment of the designated beneficial uses for these waters.

When such impairments are found, then site-specific studies directed toward determining the cause of the impairment including the specific chemical forms or organisms responsible for it, as well as the specific sources of those chemical forms or organisms that cause the use impairment in the stormwater runoff should be conducted. Best management practices should be developed to the maximum extent practicable to control real pollutants associated with stormwater runoff. An evaluation monitoring program of the type described in this paper provides the technical base of information necessary to develop technically valid, cost-effective control of real water quality problems associated with urban and rural stormwater runoff.

Additional Information

Cited in the text and listed in the references are a number of reports developed by the authors which provide background information important to developing valid evaluation monitoring programs. Copies of the authors' papers and reports on this topic, including the specific application of evaluation monitoring to the Eastern Transportation Corridor highway in Orange County, California, are available from them upon request.

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