United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-82-045 August 1982

EPA

Project Summary

Evaluation of Secondary Environmental Impacts of Urban Runoff Pollution Control

Kathryn R. Huibregtse and Anthony Geinopolos

The full report presents a generalized evaluation of the impacts associated with different urban stormwater runoff (UR) treatment techniques. The report addresses the definition of the problem, estimates the volume and characteristics of the UR and the sludges expected, evaluates six methods of UR sludge treatment, and examines alternatives and impacts for UR treatment sludge handling such as bleed/pump-back to the dry-weather plant, and land disposal.

Regarding bleed/pump-back of UR sludges, solids deposition in sewers and overload to the dry-weather facilities are anticipated to cause problems.

The most cost-effective sludge treatment alternative appeared to be lime stabilization followed by thickening, pressure filter dewatering, and landfill disposal. Secondary impacts included costs, water quality, noise, energy consumption, air pollution, and land area requirements.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Urban stormwater management is a major problem in the field of water quality management. As a result, much research, development, and demonstration of techniques for controlling and/or treating this source of pollution have been implemented. Moreover, great emphasis has been placed on the primary impacts from urban runoff pollution control, and the secondary impacts have generally been neglected.

This study is concerned with the secondary environmental impacts of urban runoff pollution control techniques. The project report summarized here presents an overview of the problems associated with handling residuals from treating urban stormwater runoff (UR) or from various housekeeping practices. The evaluation is performed for typical national areas as well as for a well-defined drainage basin.

The study's major objectives were to:

1. Provide a general definition of the sludge handling program if UR treatment is implemented on a nationwide basis.
2. Evaluate feasibility of various UR sludge handling options on a technical and/or economic basis.
3. Establish the land area requirements anticipated for implementing UR treatment and associated sludge handling.

The overall purpose of the study is, therefore, to roughly quantify the secondary impacts associated with UR management options in the United States.

Project Approach

The study's main emphasis was to evaluate impacts associated with handling the sludges generated from proposed UR treatment. Because of the difficulty in defining UR quality on a national basis, a dual approach was used: (1) National UR sludges were characterized based on published average data. (2) These were compared with sludges associated with a specific monitored urban drainage area to illustrate the differences in impacts and to emphasize the need to define each site individually.

The various methods for handling sludges from UR treatment were then investigated. Since satellite treatment of the sludges is most feasible on a generalized basis, this alternative was given the most emphasis. The high costs associated with the sludge handling, as well as the area needs for the treatment processes, indicated, however, that use of other control alternatives, such as streetsweeping, might be beneficial.

Throughout the evaluation, both primary and secondary environmental impacts were considered. Primary impacts are those that can be attributed directly to the proposed action. In this report they are considered to be water quality, cost, and land area requirements. Secondary impacts are more difficult to quantify since they are considered indirect or direct changes. The general approach was that the environmental effects can be related to induced changes in the pattern of land use, population density, and related effects on air and water quality or other natural resources. Since these criteria are most directly related to facilities construction, the main secondary impacts for this report are those effects on air and water quality. Energy consumption was also considered in this category. Costs reflect June 1977 dollars.

Limitations of the Study

This evaluation was performed to provide a generalized quantification of the problems associated with handling UR treatment residuals. Sludge quantity and quality were not obtained from studies but were extrapolated from available data for combined sewer overflow (CSO) sludges. The project effort was limited to this approach since it was believed that the extreme variabilities of UR quality would preclude an accurate nationwide assessment. It is anticipated that UR sludges must be evaluated on a site-specific basis for accurate quantifications, so a detailed national review is not required. The data are intended to alert the reader to the magnitude of the potential problems associated with UR sludge handling and should not be used for design.

Summary of Findings

Definition of the Problem

An average volume of UR on a nationwide basis was calculated to be 2.9 x 10^9 m^3/year (7.7 x 10^5 M gal/yr). The associated sludge volumes were assumed or calculated to range from 0.3 to 6.0 percent of the influent flow depending upon the treatment used and the sludge handling techniques employed.

The UR quality directly impacted the associated sludge characteristics. The selected national average for suspended solids concentration (415 mg/L) greatly exceeded a previously verified STORM model predicted value for a part of the Milwaukee River Basin area in Wisconsin (156 mg/L). As a result, sludge quantities and qualities for the two were extremely different.

Storage volume requirements were evaluated for 5-yr and 1-yr design storms at 1-hour and 24-hour durations. Total pumpout times of 24 and 48 hours were considered. The type and duration of the design storm, pumpout rates, and rainfall significantly affected the storage required. The nationwide evaluation indicated that storage volumes of 81 to 224 m^3/ha (1,160 to 3,200 ft^3/acre) were needed compared with 67 to 197 m^3/ha (954 to 2,820 ft^3/acre) for the Milwaukee River Basin.

Land area needs depend on the type of storage technique employed, the basin volume and depth, and the pumpout rate. Assuming a 4.8 m (15 ft) basin depth, national storage area requirements ranged from 0.2 to 0.6 percent of the area served by storm sewers and 0.3 to 0.4 percent for the Milwaukee River Basin.

Sludge quantities and qualities were extrapolated based on published removal efficiencies and similarities to CSO sludges. Percent solids in the UR sludges were calculated to range from 0.5 to 12 percent depending upon the treatment used and the sludge handling techniques employed.

Since storage/sedimentation was evaluated for total capture and 24-hour detention, solids removal efficiencies were high (87 percent). A flow-through mode of operation would significantly reduce the effectiveness of the treatment methods.

The quality of sludges generated by UR treatment varied significantly for the national and for the Milwaukee River Basin areas. The greatest differences were present in the sludge solids concentrations—the national values were approximately three times greater than those calculated for Milwaukee. Conversely, BOD_5 concentrations were greater in the Milwaukee UR sludges. These differences and others reflect the variation in UR qualities used in the calculations.

Nationwide, UR sludge volumes ranged from 8.8 x 10^6 to 175 x 10^6 m^3/yr (2.3 x 10^3 to 46.2 x 10^3 M gal/yr) compared with 156 x 10^6 m^3/yr (41.2 x 10^3 M gal/yr) for CSO sludge and 60.9 x 10^6 m^3/yr (16.1 x 10^3 M gal/yr) for raw primary sludge. Annual dry solids weights for UR sludges [7.5 x 10^6 metric tons (8.2 x 10^6 tons)] also exceeded calculated amounts for CSO sludge [1.7 x 10^6 metric tons (1.8 x 10^6 tons)] and raw primary sludges [2.9 x 10^6 metric tons (3.2 x 10^6 tons)].

UR sludge nutrient concentrations ranged from 502 to 1,270 mg/kg total phosphorus as P and 1,140 to 3,370 mg/kg total Kjeldahl nitrogen (TKN). These amounts were consistently lower than nutrients found in CSO sludges (2,800 to 7,400 mg/kg as P and 1,100 to 13,000 mg/kg TKN) and raw primary sludges (3,500 to 12,200 mg/kg - P and 15,000 to 40,000 mg/kg TKN).

Differences in other parameters including metals and BOD_5 were inconclusive, given the range of removal efficiencies and source variations.

Because of the intermittent nature of UR sludge generation and the sources of the runoff, grit concentrations would be expected to be high and volatile solids concentrations, low. These characteristics would probably adversely affect operation of many treatment processes.

Impacts of Bleed/Pump-Back of Urban Runoff Sludges

The problems associated with bleed/pump-back of UR sludges are similar to those evaluated with regard to CSO sludges. It is anticipated that bleed/pump-back of UR sludges may adversely affect operation of a dry-weather plant due to sludge age, high grit, and low volatile solids content.

Solids deposition in gravity flow sewers is anticipated to be a severe problem with regard to bleed/pump-back of UR sludges. Depending on the degree of capacity available at the dry-weather plant, bleed/pump-back can cause overloads with respect to solids loadings. Specifically, the solids overload caused by bleed/pump-back to the dry-weather plant detrimentally affects the primary and final clarifiers as well as those sludge handling facilities whose design is based on solids loading such as thickeners, digesters, filters, centrifuges, etc. The weight of solids associated with bleed/pump-back can be shown using population equivalents to represent service to an additional 224,000 to 316,000 people in a dry-weather plant area serving 340,000 persons. The increased solids from bleed/pump-back of UR sludges will substantially overload sludge handling processes based on solids loading and require 1.5 to 4.5 times additional capacity.

There does not appear to be any toxicity impact on the dry-weather plant due to bleed/pump-back of UR sludges when the sludge is mixed with dry-weather influent flow. Secondary impacts from bleed/pump-back are associated with transportation to a dry-weather plant or to the disposal site. Nuisance problems, air and noise pollution, and increased energy consumption are anticipated. Disposal secondary impacts involve all those associated with any dry-weather plant disposal technique with increases proportional to increases in sludge volumes (18 to 25 percent). Bleed/pump-back of the dewatering residuals generated from satellite treatment plant dewatering does not appear to cause significant overloading to a dry-weather or associated sludge handling facilities.

Impacts Associated with Urban Runoff Sludge Handling at Satellite Treatment Facilities

Review of available sludge handling processes indicated that the most applicable processes for UR sludge handling are: gravity thickening, lime stabilization and vacuum filter, or filter press dewatering. Truck transport followed by landfill or landspreading disposal were considered appropriate.

Because of the low nutrient content anticipated in UR sludges, landspreading is considered a disposal option, rather than a resource recovery method. Landspreading rates are limited by the cadmium content in sludges. Sludge loading rates range from 26.9 metric ton/ha/yr (12 ton/acre/yr) on a national basis to 33.6 to 62.7 metric ton/ha/yr (15 to 28 ton/acre/yr) for the Milwaukee River Basin sludge. Site life is 40 yrs. Of the six UR treatment sludge handling schemes evaluated for three national UR areas and for the Milwaukee River Basin area, the sludge scheme involving lime stabilization, gravity thickening, pressure filtration dewatering, and landfill disposal was most cost-effective.

Capital and annual costs associated with disposal of sludges from the Milwaukee area were less than those calculated for national areas because of the lesser weight of solids generated per unit area in Milwaukee. Annual costs, including operating costs and amortized capital costs, range from $126 to $251/ha ($51 to $102/acre) on the national level and $52 to $113/ha ($21 to $46/acre) for Milwaukee. The only UR and sludge handling alternative found to be completely inappropriate on a cost basis was swirl concentration treatment without sludge thickening followed by landspreading disposal. Total capital costs for sludge handling methods ranged from $365 to $1,390/ha ($148 to $563/acre) on a national level. Milwaukee River Basin capital costs were again substantially lower, ranging from $168 to $743/ha ($68 to $301/acre).

Land area needs for sludge handling were quite small. If storage sedimentation is involved, the processes can be located above the covered basin, eliminating the need for additional area. Swirl concentration land area needs involve only sludge handling and range from 0.4 to 0.5 m^2/ha (1.8 to 2.1 ft^2/acre) on a national basis; 0.2 to 0.5 m^2/ha (0.9 to 2.0 ft^2/acre) for Milwaukee.

Secondary impacts can be associated with the treatment system, transportation mode, and the disposal site. Evaluation of these must be performed on a site-specific basis. The potential impacts can only be identified on a general level. Treatment system impacts include nuisance associated with odor from stored sludge, reduction in area availability, increases in noise levels, and energy consumption. Transportation causes increase in noise and air pollution from travel over dusty roads and emissions. Energy uses are also greater. Disposal secondary impacts are most significant. They include those associated with surface or groundwater contamination, increased use of available disposal area, higher instances of vectors, noise and air pollution, or impact on sensitive/unique areas. Proper operation of disposal sites should minimize these problems.

Land Disposal of Storm Generated Sludges

It is believed that wet-weather flow sludges can be incorporated into EPA sludge land disposal programs. The problems associated with this incorporation are not insurmountable.

The quantity of UR and CSO sludges requiring disposal is about the same magnitude as that of dry-weather sludge. Therefore, a significant amount of additional land will be required for land utilization of wet-weather sludges (CSO and UR) over that needed for dry-weather sludge (see Table on following page).

Dry-weather and UR sludges are distributed relatively uniformly over the United States. In contrast, CSO sludges are concentrated in the Northeast and Great Lakes regions of the country. Therefore, separate or codisposal of dry- and wet-weather sludges will be a more formidable problem in the Northeast and Great Lakes region. Dry-weather sludge is considered a low grade fertilizer based on nutrient content. UR and CSO sludges, in comparison, may be considered lower grade fertilizers. Wet-weather sludges may be disposed of by landfilling or may be applied on land. Design criteria are available for each method. Sludge application rates are appreciably greater for landfilling disposal than for land application. Disposal of liquid wet-weather sludges on land will see limited use because the relatively low (<15%) solids concentration is not applicable to wet soils during or immediately after heavy rainfall and is cost-effective only for short distances [8 to 16 km (5 to 10 miles)] from the treatment site. Therefore, wet-weather sludges will have to be pretreated before being applied on land.

The most applicable pretreatment processes for handling wet-weather sludges for land disposal are storage, thickening, lime stabilization, and filtration dewatering.

☆ U.S. GOVERNMENT PRINTING OFFICE. 1982 -559-017/0770

Sludge	Annual Sludge Volume 10^6 m^3	10^3 gal	Average Percentage Solids
Dry weather	*125.0*	*33.0*	*2.3*
CSO	*157.0*	*41.5*	*0.3-6*
UR	*8.8-175.0*	*2.3-45.5*	*0.5-12*

Although costs for land use of wet-weather sludges have been estimated, these costs should be used only for preliminary work as actual costs may vary considerably with specific local conditions.

Recommendations for Future Research

- The quantity of UR sludges should be defined through on-site testing to determine if the actual quantities are similar to those predicted in this report.
- Associated water quality impacts after streetsweeping and UR treatment should be evaluated in more detail to provide needed justification for implementing management procedures.
- Actual removal efficiencies for storage/sedimentation treatment over extended treatment periods should be verified on a large scale.
- Swirl concentration treatment removal efficiencies for nitrogen and phosphorus should be established by on-site testing.
- Secondary impacts associated with disposal techniques should be evaluated. Leachate qualities from UR sludge or streetsweepings should be established by lysimeter or other appropriate testing.
- A nationwide survey should be made of land area availability in densely populated city areas.
- A user's manual or handbook should be prepared, which is similar in nature to those prepared for land utilization of domestic sludges, but specific to land utilization of wet-weather sludges (UR and CSO).

The full report was submitted in partial fulfillment of Contract No. 68-03-2574 by the Environmental Research Center of Rexnord, Inc., under the sponsorship of the U.S. Environmental Protection Agency.

Kathryn R. Huibregtse and Anthony Geinopolos are with Rexnord, Inc., Environmental Research Center, Milwaukee, WI 53214.
***Anthony N. Tafuri** and **Richard Field** are the EPA Project Officers (see below).*
The complete report, entitled "Evaluation of Secondary Environmental Impacts of Urban Runoff Pollution Control," (Order No. PB 82-230 319; Cost: $12.00, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
*For information contact **Richard Field** at:*
Storm and Combined Sewer Section
Municipal Environmental Research Laboratory-Cincinnati
U.S. Environmental Protection Agency
Edison, NJ 08837