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Operation DO-IT and Operation TIDE: Controlling Chlorine in the Environment

1981 PROGRAM

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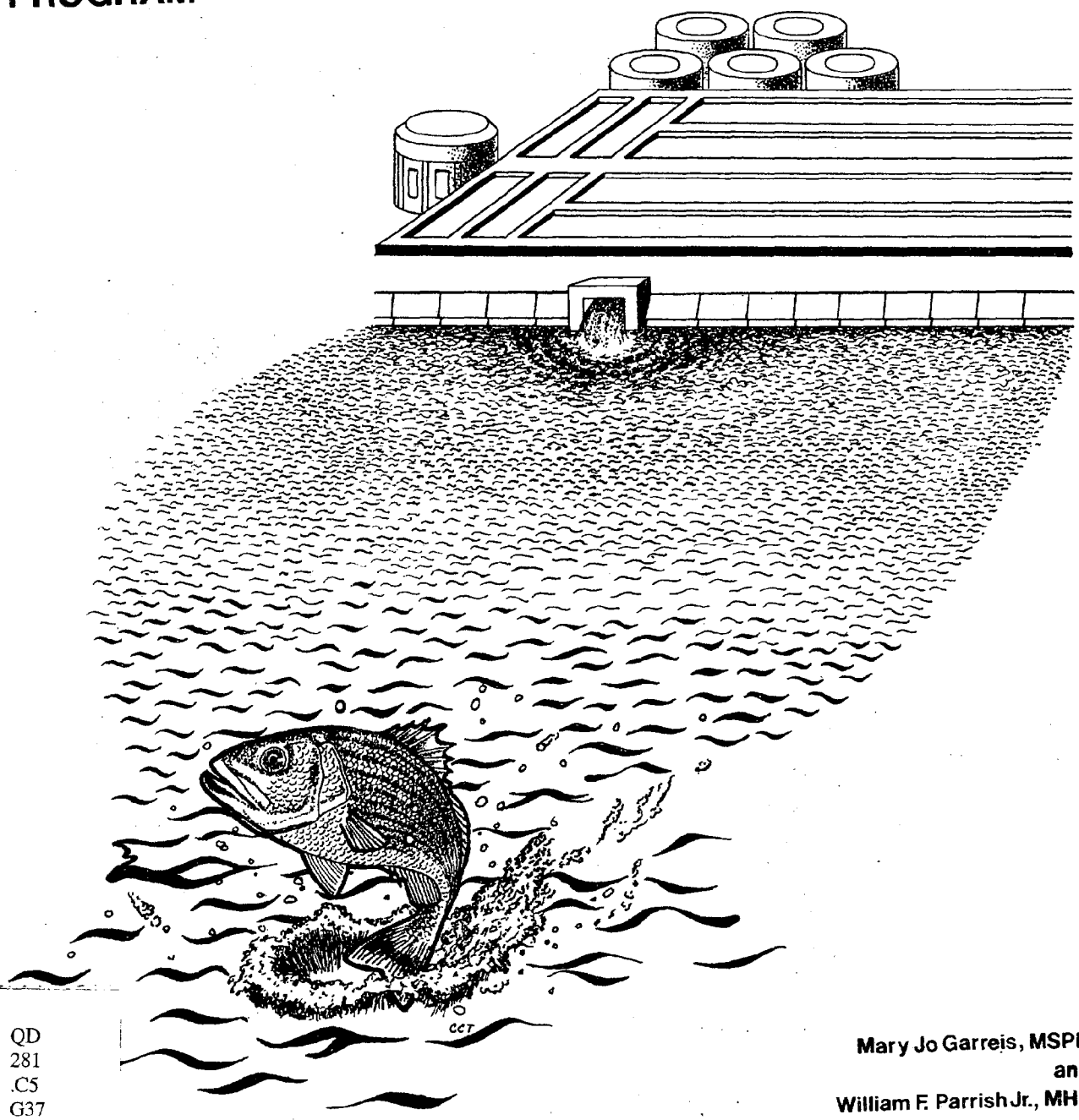

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ABSTRACT

In 1981, the Department of Health and Mental Hygiene and the Department of Natural Resources joined together in a project called Operation DO-IT (Operation Disinfection Optimization-Innovative Techniques) in order to improve existing chlorination facilities and to reduce the amount of chlorine discharged to fish spawning areas. A team worked with forty wastewater treatment plants identified by Maryland Department of Natural Resources as potentially harmful to anadramous fish spwaning in the Maryland portion of the Chesapeake Bay. The team worked with the plant owner/operator to make recommendations for improvement of chlorination system facilities and operation, make on-site modifications and implement improved operation procedures. The results of this project showed that the existing chlorination facilities at the plants which were surveyed required some form of modification in order to enhance the system performance. System deficiencies which were identified and corrected included inadequate chlorine solution diffusers, poor location of the diffusers, short-circuiting of flow in the chlorine contact tank, over-dosing of chlorine solution, and poor control of chlorine gas feed as a result of over-sized chlorination rotometers. These improvements should provide long-term benefits in terms of reducing amounts of chlorine required for disinfection.

Efforts of the team in Operation DO-IT were coupled with the concept of Operation TIDE (Temporary Installation of Dechlorination Equipment). After improving chlorination facilities to optimize their performance, the team evaluated the level of chlorine being discharged and determined if dechlorination was necessary. The Department of Natural Resources provided funding to install temporary dechlorination facilities for the fish spawning season at selected sewage treatment plants. Where capacity was available, lagoon effluent holding was utilized during the spawning season.

As a result of these two projects, an overall reduction of 66% in the amount of total residual chlorine discharged to the targeted spawning areas was achieved. In three critical areas, total residual chlorine loadings were reduced by greater than 90%. Adequate data were not available to assess the impact of the reductions on fish spawning activity.

INTRODUCTION

Wastewater disinfection has been used as a valuable public health practice for the protection of water supplies, contact recreation areas and shellfish beds. In the United States, the primary agent of wastewater disinfection is chlorine, an effective biocide, disinfectant and antifouling agent. Chlorine has the capability of affecting organisms, whether harmful or beneficial, since it is not specific to target life form. In addition, chlorine is readily available, inexpensive compared to other disinfectants and is fairly easy to handle and measure. Recent scientific data, however, suggest that chlorine has the potential to cause adverse impact in the environment.

Extensive literature exists on the biological effects of free and total residual chlorine on freshwater and some marine organisms under controlled laboratory conditions. The majority of the literature addresses acute or chronic impacts on eggs, larvae or juveniles. There is little in the literature, however, concerning field studies using indigenous species.

Considered as a whole, the range and diversity of information on the lethality of chlorinated effluents indicates that several factors influence toxicity in the aquatic environment. Biological effects associated with exposure to chlorinated effluents vary with the aquatic species, the stage of development of each species, the water quality characteristics of the stream and the characteristics of discharged effluent. Such a high degree of variation exists that site-specific determination of environmental impact is needed.

The growing scientific data concerning the potential effects of chlorine in the environment has caused some fisheries biologists to suggest that chlorine may be responsible for the decline of anadramous fish populations in the Chesapeake Bay. This theory is based on extrapolation from the existing scientific literature. Because anadramous fish populations are declining in Maryland and because the scientific data is sufficient to presume that chlorine could cause an undesirable stress on spawning fish and eggs, the Office of Environmental Programs, Department of Health and Mental Hygiene and the Tidewater Administration, Department of Natural Resources entered into two joint projects to reduce the level of chlorine and chlorinated compounds discharged to critical fish spawning areas.

METHODS AND MATERIALS

The first step identified as necessary for reduction in the discharge of chlorine to the environment was the improvement of existing chlorination facilities. Chlorination as a form of wastewater disinfection is practiced widely in Maryland as well as the rest of the United States. Too often in the past, however, the practices have been inefficient and have relied on increased chlorine doses rather than efficient design of the facilities and proper operation to achieve disinfection. Through the recent application of chemical

engineering principles to the environmental field, engineering optimization of chlorination systems has resulted in several design improvements (Robson et al., 1975). Rapid mixing of chlorine and improved design of chlorine contact chambers to provide sufficient actual retention times by promoting plug-flow conditions, which are essential for achieving the desired bacteriological and viral inactivation while maintaining a minimum residual chlorine discharge, are now required for new plant construction. Emphasis on correction of these deficiencies in existing chlorine wastewater treatment plants by the Maryland Department of Health and Mental Hygiene field engineers has resulted in steady improvement in chlorination practices.

Recent research has shown that in many cases the performance of existing chlorine contact facilities can be substantially improved with a minimum of effort and expense (Sepp 1976, Hart 1981). Through a program to improve existing chlorination facilities, in a short time frame, the Office of Environmental Programs and Tidewater Administration joined together in a project known as Operation DO-IT (Disinfection Optimazation-Innovative Techniques). The Office of Environmental Programs formed a special team comprised of two engineers and a senior sanitarian who were familiar with wastewater treatment plant design, operation and discharge requirements. The team worked on a case-by-case basis to reduce the final total residual chlorine loading in wastewater treatment plant effluents identified by the Department of Natural Resources as having a discharge which might adversely affect anadramous fish spawning areas. Every effort was made to make rapid modifications to the chlorine facilities to improve their effectiveness.

The team examined chlorination facilities with the plant operators, determined what minor modifications were necessary, arranged for or installed the modifications and followed up on the results of the modifications. Funding for the purchase of the necessary supplies, such as plywood, lumber, nails, diffusers, rotometers, etc. which were necessary to make rapid modifications was provided through the Department of Natural Resources. This approach provided immediate improvements which remained in place to reduce chlorine discharge year-round.

Concurrent with Operation DO-IT, the two Departments sponsored a second project known as Operation TIDE (Temporary Installation of Dechlorination Equipment). The objective of TIDE was to reduce the total residual chlorine (TRC) in wastewater treatment plant effluents to $\leq$ 0.5 mg/l through the installation of temporary dechlorination systems. Although improvement of the chlorination facilities at a number of plants included in the DO-IT project reduced the final TRC through improved mixing or contact time, these improvements were not sufficient in some cases to achieve the desired $\leq$ 0.5 mg/l TRC. At other plants, physical modifications could not significantly alter the final TRC. In both of these cases, temporary dechlorination facilities were installed in order to limit effluent TRC concentrations to $\leq$ 0.5 mg/l while maintaining adequate disinfection.

These dechlorination facilities were generally of two types:

1. Sulfur dioxide additions; or

2. Sodium metabisulfite solution introduced by:

   a. mechanical feeder or

   b. drip feed method.

In addition, one facility used sodium thiosulfate for dechlorination.

Operators of lagoons participating in the project were encouraged to draw down water levels in advance of the project and to hold effluents for 30-60 days depending on the reserve capacity available. Effluents from lagoons with 30 day reserve time available were dechlorinated from April 1 to April 15 and May 15 through June 1. As a result, since April 15 through May 15 was identified as the peak period of spawning, no discharge from these lagoons was maintained.

RESULTS

Forty wastewater treatment plants were identified as potentially impacting fish spawning areas by the Tidewater Administration, Department of Natural Resources. These plants ranged in size from an average discharge of 15,000 gpd to 15 mgd. Twenty-two of the forty wastewater treatment plants were involved in Operation DO-IT, the project which addressed improvements to the chlorination facilities. Table 1 summarizes, the findings of the initial survey by the Office of Environmental Programs' team and the subsequent improvements made.

TABLE 1 Chlorine Contact Chamber (CCC) Modifications

CCC Modifications	Plants Examined	No. of Plants Changes Made
Reconstruct diffuser	40	11 (28%)
Relocate diffuser	40	14 (35%)
Baffles	40	3 (8%)
Reduce chlorine feed	40	14 (35%)
Rotometer size modified	40	2 (5%)

Twenty-two of the 40 (55%) plants identified for the two projects required some modifications to the chlorination facilities. Nine of eleven

plants requiring reconstruction or replacement of the chlorine diffuser also required relocation of the diffuser. Fourteen (35%) of the wastewater treatment plant owner agreed to attempt to operate with reduced chlorine application. Achievement of good disinfection was measured by coliform levels remaining in the effluent following disinfection.

The need for baffling to increase the effectiveness of chlorination was identified by dye testing of chlorine contact chambers. Seven chlorine contact chambers were dye tested and the need for baffling was identified in five wastewater treatment plants. Only three plant owners elected to install baffles identified as necessary to improve actual detention time.

Operation TIDE involved 34 of the 40 wastewater treatment plants discharging to fish spawning areas. Four of the remaining six wastewater treatment plants either met the objective of an effluent total residual chlorine concentration of 0.5 mg/l or less, or had existing dechlorination equipment in place. An additional two wastewater treatment plants had insufficient space for the installation of dechlorination equipment. Six of the forty facilities were lagoons. Water levels were lowered in five lagoons and all discharge held from April 1st thru June 1, 1981. At the sixth lagoon, after holding effluent for twenty-one days, the operator was forced to discharge and used sodium metabisulfite to dechlorinate for the remaining forty days.

Dechlorination systems were installed at the remaining twenty-eight wastewater treatment plants. Generally, at plants discharging an average of 1 mgd or more, sulfonators were used to apply sulfur dioxide as this system was the most cost-effective. At the seventeen smaller wastewater treatment plants, sodium metabisulfite addition was used. This dechlorination method was the most cost-effective for small systems and was easy to install and maintain. At one plant, sodium thiosulfate was used initially, but later replaced with sodium metabisulfite because of the lower cost.

The installation of temporary dechlorination equipment, Operation TIDE, resulted in an overall reduction by 66% of the total residual chlorine discharged to the fish spawning areas in the river basins involved. Table 2 shows the average loading of TRC in lbs/day to the spawning areas. Spawning areas are grouped by river basin.

TABLE 2 - Reduction in Chlorine Discharged to Fish Spawning Areas

Fish Spawning Area by River Basin	Average TRC Discharged Before 4/1/81 lbs/day	Average TRC Discharged After 4/1/81 lbs/day	Average TRC Reduced (lbs/day)	% Reduction
Chester River	23.5	0.2	23.3	99.0
Choptank River	21.4	1.8	19.6	92.0
Nanticoke River	7.0	5.0	2.0	29.0
Patuxent River	598.0	228.0	370.0	62.0
Pocomoke River	16.7	5.5	11.2	67.0
Potomac River	108.0	20.0	88.0	81.0
Sassafras River	0.2	0.0	0.2	100.0
Upper Chesapeake	131.0	40.0	91.0	69.0
Wicomico River	116.0	43.5	72.5	62.5
Overall Average	1022	344	672	66

The data shown in this table was obtained from average flow and TRC measurements reported in plant operating records. Average chlorine loadings for each plant included in the project were calculated and summed for each river basin for a three month period prior to April 1, 1981, and for the period after April 1st to June 1st. This data is shown in columns 1 and 2, respectively. The third column shows the difference between columns 1 and 2 and indicates the reduction in the amount of TRC discharged in the respective spawning areas during the project period. The last column shows the overall percent reduction.

Not all wastewater treatment plants were able to install equipment or begin operating by the target date of April 1st, therefore, 100% reduction was not achievable in all locations. Conversely, dechlorination equipment at several plants was in operation as early as March 15th and the spawning area may have received some additional benefits from the reduced chlorine discharge during this early period.

Project costs varied depending on the size of the plant, the modifications to the chlorination facilities, and the type of dechlorination system used. Project cost for Operation DO-IT ranged from $75.00 to $245.00 per plant. Project costs for Operation TIDE, the temporary dechlorination facilities, ranged from a low of $250.00 to a high of $4100.00 per plant. Total project costs were $26,700. These costs were well below our original estimate because the Washington Suburban Sanitary Commission absorbed the cost of installing and operating dechlorination facilities at three major plants.

Two of the forty wastewater treatment plants which participated in the 1981 Operation TIDE elected to continue dechlorination on a year-round basis. These wastewater treatment plants retained the equipment purchased in the project. By 1982, an additional 8 wastewater treatment plants included in the project will have permanent dechlorination facilities. The dechlorination facilities will be part of the wastewater treatment plant upgrading accomplished through the 201 facility planning process.

DISCUSSION

Both Operation DO-IT and Operation TIDE were well received by the participants and the public. Cooperation from the wastewater treatment plant owners and operators was generally readily forthcoming and enthusiastic. Plant operators were particularly receptive to suggestions from the project field team on temporary equipment installation and minor modifications to improve chlorinations system efficiencies. Without their cooperation, we could not have achieved the objectives of these two projects in such a short time frame.

The media gave good coverage throughout the projects. Numerous information requests were received from citizens, from state agencies outside Maryland and from environmental groups. Responses from the public, newspaper articles, and press releases were positive.

At this point in time, it cannot be demonstrated scientifically that Operation DO-IT and TIDE enhanced the success of fish spawning activities in 1981. The approaches used reduced the chlorine discharged to spawning areas

from 29% to 100% depending on the river basin involved. Although there were no studies made to measure reproductive activity and egg or juvenile survival rates during April, May or June 1981, information released by the Tidewater Administration following the 1981 fall anadramous fish survey reported poor year class recruitment. Furthermore, because field monitoring equipment for chlorine residual is not reliable at levels of $\leq$ .05 ppm, particularly in brackfish spawning areas, we were unable to measure the low level chlorine residual in the environment. The only reliable information we were able to obtain was the final total residual chlorine released in the effluent. These measurements are subject to analytical limitations. Nevertheless, because of the substantial reductions in chlorine discharges which were made possible through these projects, it is safe to conclude that some environmental benefits were obtained.

The Office of Environmental Programs, through its enforcement activities involving wastewater treatment plants, has emphasized compliance with NPDES permit limitations on coliform bacteria and residual chlorine. Although some operational problems exist in terms of chlorine dose and residual measurement, emphasis on correction of these deficiencies by the Office of Environmental Programs' field engineers has resulted in steady improvement and correction of existing problems. The majority of major wastewater treatment plants today are in compliance with NPDES chlorine limitations or are implementing technology to achieve compliance. At the same time, adequate disinfection of wastewater effluents is being maintained.

If the hypothesis that chlorinated wastewater treatment plant effluents cause an undesirable stress on fish reproduction is correct, Operation DO-IT and TIDE contributed substantially to the reduction of this stress during the critical fish spawning period. Whether the elimination of this one factor is sufficient to enhance year class recruitment remains to be seen. These projects will be repeated in 1982 and perhaps more information will become available.

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