mathematical model calculates the overflow concentration qualitatively and quantitatively very accurate. The model gives a slightly lower concentration. This has to be taken into account when the calculated data are used to predict loads to a receiving water.

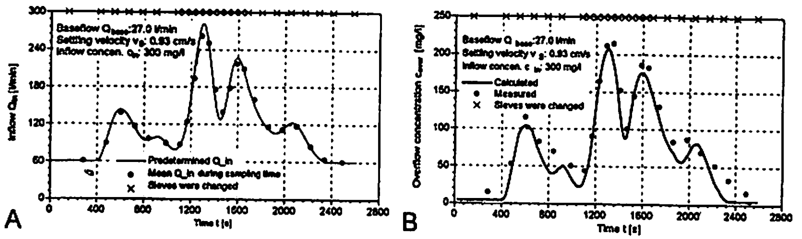

Fig 6: Simulated storm event in the laboratory

All in all five storm events were simulated in the laboratory. The difference between calculated efficiency with the steady state model and the measured efficiency for the storm events never exceeded 2 percent points.

## CONCLUSIONS

- Influences on the separation process which has to be taken into account are: hydraulic load, flow ratio and settling velocity of the combined sewage constituents.
- The influence of inflow concentration and unsteady state conditions on the separation process are very little. For a practical application they can be neglected.
- The separation process can be described by a quasi steady state approach.
- At a surface load higher than 2.4 times the settling velocity of the particles no separation takes place. At surface loads less than 0.25 the settling velocity a 100 percent efficiency can be expected.
- The mayor advantage of the hydrodynamic separator compared to a circular settling tank is that no operational maintenance is necessary. The effectiveness as a quantity for the separation process is only slightly higher for the hydrodynamic separator.


## ACKNOWLEDGEMENT

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# OVERFLOW CONTROL AND TREATMENT SYSTEMS. OPTIMIZATION OF THE STORAGE-SEDIMENTATION TANK BINOMIAL.


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**KEYWORDS:** Combined sewer overflows (CSO); storage; sedimentation; settling; receiving water; rivers; organic matter; rain; water quality standards.


## INTRODUCTION

With storm water management programs, there is a strong tendency to consider the volume of rainwater and its effects, such as flooding, and to forget the impacts which these waters have on the quality of the receiving water. However, the contaminants carried in these waters may provoke very important long term effects, which in many cases, constitute the most critical management aspect.

Normally, and above all in stages with gradients of less than 1%, the minimum flow during dry periods is not sufficient to clean the network, causing sedimentation in the pipes. With the onset of rain, the network cleans itself out. The increase in flow implies an increase in the velocity of the water in the network, permiting the particles deposited in the pipes to be carried away. Rains following a dry spell carry off a considerable load of contaminants which had accumulated in the sewer network. It is therefore vitally important to control and treat sewer network overflows in order to guarantee receiving water quality. The use of both storage and settling tanks can be a good solution to this problem.

The methods currently employed in different countries for designing overflows are based on empirical criteria obtained from observing real cases. The design criteria for overflow tanks do not usually coincide. For example, in Germany (ATV-128, 1992) the objective was that the COD load of the overflows of a unit network did not excede the corresponding load of a separative system (overflows plus EDAR effluent). In some French Departments (Thu Thuy, 1988) the system was sized to retain 6 times the average dry period flow for 20 minutes.

Another criteria used in parts of France and Germany is that of the critical rainfall (Thu Thuy, 1988). Storage tank volume is calculated by a design intensity or a critical intensity and some nomographs which depend on the EDAR characteristics. In Spain, the Confederación Hidrográfica del Norte (1989) used values which oscilate between 4 and $7 m^3/ha$ imp. depending on the population density of the basin.

In experimental studies which have taken into account the phenomenon of sedimentation and resuspension in the sewer network, Bachoc et al (1993) consider 100 to 200 $m^3$/ha imp. to be necessary. In the case of nutrients entering sensitive lake environments Hvitved-Jacobsen (1993) mention figures of around 200 to 300 $m^3$/ha imp. Saget et al (1995) obtain storage volumes which retain 80% of the solids in suspension with unit networks of between 31 and 68 $m^3$/ha imp. According to Provoost (1993), storage tanks of 70$m^3$/ha imp. should be used along with sedimentation tanks of 20 $m^3$/ha imp. for existing unit networks.

The sizing of storm water detention tanks is a field which needs further research in order to iron out the existing lack of uniformity.

## OBJECTIVES

An attempt was made to obtain design criteria for storm water retention tanks by using computer simulated models, which could then be compared with the previously mentioned empirical criteria. The aim was to find the minimum combined storage-sedimentation tank volume which resulted in an acceptable river $BOD_5$ impact from the overflows on the rivers.

## METHODOLOGY

This work has tried to simulate the worst possible situation for the receiving water. For this purpose, the dry period was chosen (minimum flow which permits a small dilution), adopting a flow 10 times the average dry flow of the sewage. It is also assumed that the studied rainfalls occurred after 7 rain-free days, enough time for sufficient waste to accumulate both over the city surface and in the sewer system to appreciably increase the contamination of the waters. An unfavourable gradient (0.3%) has been assumed for the sewer system.

The basin chosen for the study is located in an urban area and has a surface area of 6 hectares. The population density has been taken as 100/ha imp. and the supply of water to the system as 250 L/person per day. The capacity of the treatment plant located downstream of the overflow control system has an approximate inflow 4 times the dry weather average flow.

Previous studies of urban runoff pollution provided the rainfalls capable of carrying away most of the contamination which had accumulated on the surface of the city. Two unfavourable rainfalls were chosen: one of long duration and light intensity (10 mm/h and 200 minutes), and another of strong intensity and short duration (120 mm/h and 25 minutes).

The combination of a control structure, a storage tank and a conventional sedimentation tank was used as the overflow control and treatment system. The mission of the control structure is to limit the maximum flow going to the waste water treatment plant. The tank takes care of the first flow entering the sewer system after the onset of rainfall (the one which carries away the greatest quantity of contaminants) while the flows return to normal and permits the treatment of this initial water volume. If the tank is not large enough to retain the excess water which cannot be treated at the plant, the settling tank reduces the contamination in the overflow



water. After a previous study, the storage tank was located off line (without mixing with later waters) and the sedimentation tank in the line of the overflows, resulting in 15% less total volume compared with other alternatives.

The Storm Water Management Model (SWMM) of the U.S. EPA was used for simulating the hydrograms and pollutograms in the network as well as the overflows. The simulation of the storage tank was made by trimming the hydrogram and that of the sedimentation tank by using the option of efficiency as a function of hydraulic retention time.

To determine the final concentration of $BOD_5$ in the river, it was assumed that the mixing of the receiving and entering waters is total and instantaneous. In this way the maximum and average concentrations of pollution events in the river have been calculated.

The base quality criteria chosen are those of the Spanish standard for piscine river life. Thus requiring maximum $BOD_5$ concentrations of 6 mg/l for *Cyprinidae*, and 3 mg/l for *Salmonidae*. Having simulated extreme rainfalls which produce maximum contaminant presence in the river, it was considered that being exceptional, then an increasing coefficient may be applied to the values given in the standard. Therefore, the levels of contamination stipulated in the said standard have been allowed to be surpassed, considering the isolated nature of the phenomenon and its short duration. Hence, in the dynamic criteria of the WRC (Lijklema, 1993) for non ionized amoniacal nitrogen concentration it was possible to establish increasing coefficients relative to its base level of between 1.5 and 2 for events of 6 hours and of 3 and 4.5 for instantaneous events. Nevertheless, from the data of the Danish Water Pollution Control Committee (House et al., 1993) decreasing coefficients could be established for disolved oxygen of between 1.5 and 3 depending on the return period and the water quality required.

For the average concentrations of $BOD_5$ in the river volumes of 1.5 to 2 were taken for the increasing coefficient (the concentration of the contaminant in the river may be 1.5 to 2 times that required by the standard). In the case of maximum concentrations the increasing coefficient may oscillate between 3 and 4.

## RESULTS AND DISCUSSION

Sixty three different combinations of volumes for storage and sedimentation tanks have been selected in the range of 0 - 150 $m^3$/ha imp. for each tank. The overflows and their impact on the river have been simulated for each of these values. This has been characterised by the maximum and average $BOD_5$ concentrations for the pollution events in the river. The maximum and average $BOD_5$ isoconcentrations in the river are represented in the graphs storage tank volume (x) - sedimentation tank (y) for the overflows produced by the unfavourable rainfalls, both the light prolonged rainfall (Fig. 1) and the short intense rainfall (Fig. 2).

Intersecting these isoconcentration curves by assuming sedimentation tank volume + storage tank volume = constant, it is possible to obtain the geometric location of the solutions of minimum total volume for each average or maximum concentration in the river. Taking as reference concentrations in the river those which correspond to the previously established dynamic quality objectives, the optimum storage-sedimentation tank combinations which fulfill the required quality levels have been established.

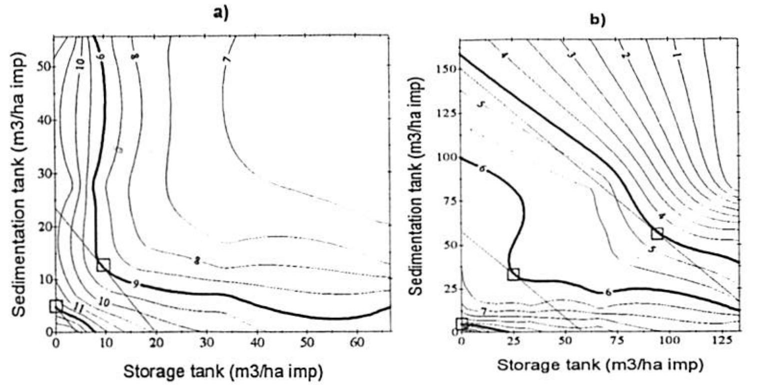


**Fig.1.-** Maximum (a) and average (b) $BOD_5$ isoconcentrations in the river as a consequence of overflows produced by prolonged rainfall of 10 mm/h and 200 min., for different combinations of storage and sedimentation tank volumes.

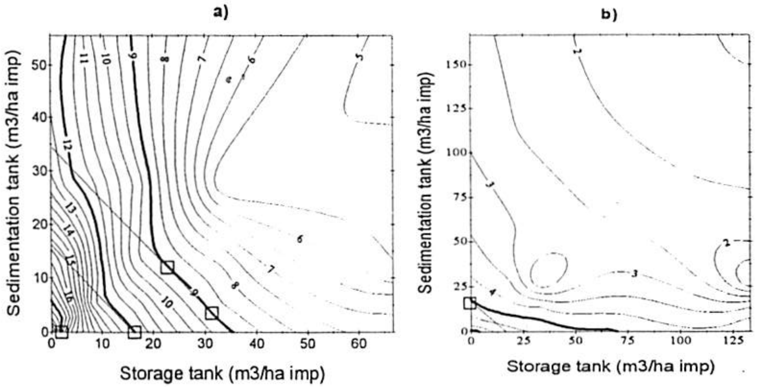


**Fig.2.-** Maximum (a) and average (b) $BOD_5$ isoconcentrations in the river as a consequence of overflows produced by intense rainfall of 120 mm/h and 25 min., for different combinations of storage and sedimentation tank volumes.

The intense rainfall (120 mm/h and 25 min.) produces greater maximum concentrations in the river, while the prolonged rainfall (10 mm/h and 200 min.) provokes greater average concentrations.



In general, the storage tank is useful for reducing the values of the maximum concentrations in the river, while the sedimentation tank is useful for reducing the average concentrations.

The optimum solution for reducing the impact on the river is obtained, except in special cases, by a combination of storage and sedimentation tanks.

To obtain the quality objective for *Cyprinidae* a sedimentation tank of 0 to 5 $m^3$/ha imp. is needed to reduce the average concentration produced by the prolonged rainfall and a storage tank of between 0 and 2 $m^3$/ha imp. to reduce the maximum concentration caused by the intense rainfall. The overall solution would need between 0 and 6 $m^3$/ha imp. of which between 0 and 1 $m^3$/ha imp. corresponds to the storage tank.

For the water quality established for *Salmonidae*, a total tank volume of between 60 and 150 $m^3$/ha imp. is needed, between 30 and 60 of which correspond to the sedimentation tank and between 30 and 90 to the storage tank. The most critical design factor corresponds to the average concentrations produced by lasting rainfall.

Our results embrace a range which is as ample as that of the reviewed literature, the preestablished water quality of the receiving body being the most diversified element. The lowest design volumes reported (Confederación Hidrográfica del Norte, 1989; Thu Thuy, 1988) would correspond to the quality goal established for *Cyprinidae* in the river, while the greatest values reported (Bachoc et al., 1993; Provoost et al., 1993; Saget et al., 1995) are in the order of the design volumes established for *Salmonidae*. Although the volumes determined by Saget et al. (1995) are somewhat lower, greater volumes appear in the case of trying to treat or reduce the pollution caused by the most unfavourable rainfalls, as is the present case. On the other hand, our results are conditioned by the values of the increasing coefficients used in the definition of criteria of dynamic quality for $BOD_5$, as well as by the specific characteristics of the basin and the methodology followed.

Increasing the volume of the sedimentation tank located off line is useful in the case of intense rainfalls (120 mm/h and 25 min.), up to a maximum value of around 14 to 28 $m^3$/ha imp., because for greater values the pollution entering the receiving body is more reduced by increasing the volume of the storage tank.

## CONCLUSIONS

In the presented case, for fulfilling the river water quality requirements for *Salmonidae* the total tank volume is found to be between 60 and 150 m, of which between 30 and 60 $m^3$/ha imp. correspond to overflow sedimentation and the rest to storage. In the case of *Salmonidae*, the total volume necessary oscillates between 0 and 6 $m^3$/ha imp. of which 0 to 1 $m^3$/ha imp. should be dedicated to overflow sedimentation. The most unfavourable rainfall has turned out to be the prolonged, low intensity precipitation.

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# ALTERNATIVES TO SCREENS IN CONTROLLING AESTHETIC POLLUTANTS

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KEYWORDS Regulation, aesthetic pollutants, combined sewer overflow, sewerage

## ABSTRACT

Two research projects were commissioned by the UK Water Industry to investigate strategies for satisfying the regulators' response to the requirements of the EC Urban Wastewater Treatment Directive regarding aesthetic pollution from combined sewer overflows. The design criteria for aesthetic pollution are expressed in terms of the performance of 6mm mesh screens and 10mm bar screens. The initial project identified that the effects of applying the new criteria were not fully understood and that effective overflow design provided an alternative solution to screening.

The paper describes the results of the second project which set out to clarify the points identified in the first. Different permissible rainfall inputs have been analysed and recommendations made for use of full and sample local rainfall series. A structured study of 8 drainage areas containing 51 CSO's simulated in 5 different geographical locations has been undertaken. A number of design options which could prove more cost effective than the provision of screens are identified and in particular the integrated use of hydrodynamic separation and storage is recommended. The study highlights the need for computer software to post process the output from hydraulic simulations and relevant routines have been developed. A procedure for the design of combined sewer overflows is proposed. The intensive analysis also indicates anomalies in the guidelines. Recommendations for re-specifying the design criteria are made together with an interim solution.