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Quantitative and Qualitative Characteristics of Urban Discharge to Small River Basins in the South West of Sweden

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The paper deals with the qualitative and quantitative characteristics of urban discharge. Ratios for urban discharge and recipient flow during different time intervals are presented and discussed. The quality of the urban discharge is illustrated through pollutographs.

Introduction

In the southwest of Sweden a common recipient for urban discharge is small rivers and creeks. These rivers usually discharge into Öresund, the sound between Sweden and Denmark (Fig. 1). The river basins contain small cities and towns surrounded by agricultural areas.

There is great variety in the use of the river water, such as for irrigation and for live stock. The areas around the rivers also represent important recreational and outdoor values for the densely populated southwest of Sweden. Canoeing, sport-fishing and swimming are examples of activities connected with the rivers. However, water quality can deteriorate due to urban discharge and recreational use is often threatened.

The receiving waters for the city of Lund, Höje river (Fig. 2), is a typical recipient of urban discharge and representative for the southwest of Sweden.

During the project "Quantitative and qualitative water budget for the city of Lund" (Hogland et al. 1979, 1980), extensive measurements were carried out to estimate the total discharge from the city, in quantitative and qualitative terms,

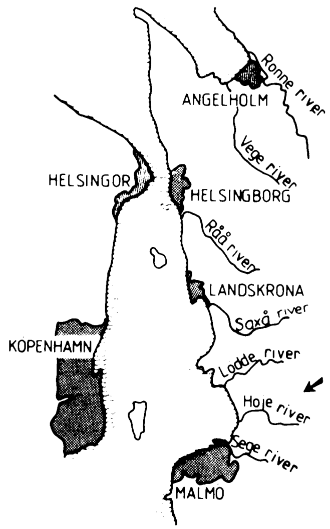


Fig. 1. Water courses in the southwest of Skåne.

and simultaneously related to the river flow. The importance of the urban discharge was recognized; especially during low-flow periods, emerging from natural variations in river flow.

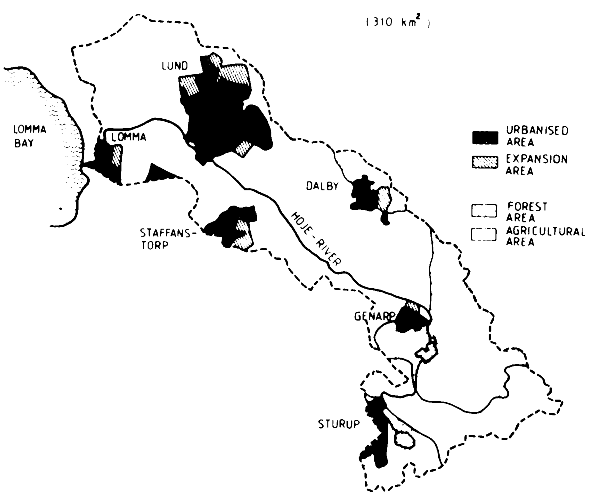


Fig. 2. Landuse within the Höje river basin.

Riverflow and Urban Discharge

The variations of flow in the Höje river range from 0.1 to 100 m^3/s or more, in a normal year. The maximum flow often occurs during snow melt when water from both urban and rural areas contributes to the runoff.

The "Low Riverflow Effect" (Falk et al. 1980) arises when discharge from urban areas constitutes a major part of the total riverflow. From the ratio between the urban discharge and the natural riverflow, together with ecological data, it is possible to identify critical periods, when urban discharge has marked influence on the ecological conditions of the recipient. For the Höje river the urban storm water to riverflow ratio can be as great as 25 for separate flowvalues.

The "Low Riverflow Effect" usually occurs during summer when the riverflow is extremely low and when heavy rainstorms occur. In the following sections, the impact of different kinds of urban discharge on the riverflow are quantified.

Treated Wastewater

During dry summer periods the riverflow is dominated by discharge of treated wastewater. In Fig. 3 the flow in the Höje river is compared with the treated wastewater discharge from the city of Lund. On basis of the figure, it is possible to identify periods when the flora and fauna depend mainly on the quality of treated wastewater and not on the natural conditions in the river.

The earlier described low riverflow effect can be visualized by calculating the ratio between discharge of treated wastewater and the natural riverflow on basis of different timescales (Fig. 4).

Fig. 4 shows the maximum average ratio for various time-scales and is valid for dry periods between precipitation events.

Stormwater

Heavy convective precipitation is common during June to August in Sweden and often causes an extreme increase in the river flow. The ratio between the urban

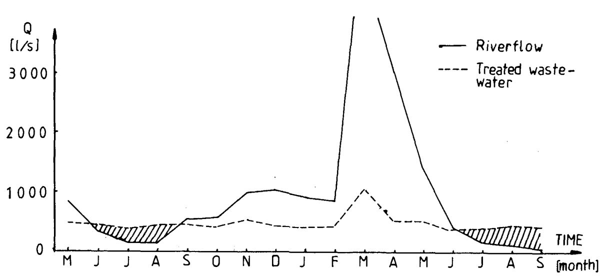


Fig. 3. Flow in the Höje river compared with the discharge of treated wastewater.

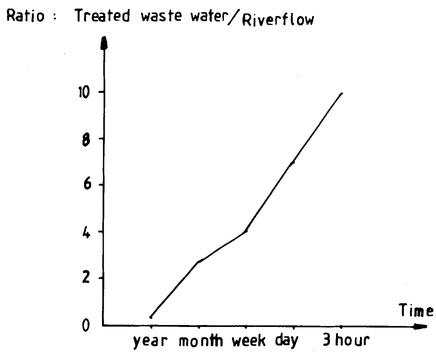


Fig. 4. Ratio between discharge of treated wastewater and the natural river-flow for different time-scales.

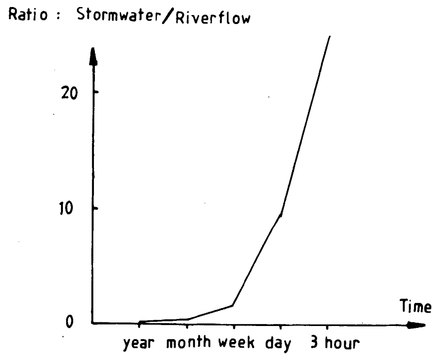


Fig. 5. Ratio between discharge of urban stormwater and the natural river-flow for different time-scales.

stormwater runoff and the normal river flow is illustrated in Fig. 5. Biological activity is higher during the summer, which makes the rivers more susceptible to the impact of pollution and to toxic shock effects. Since urban stormwater runoff often exceeds river flow by several-fold. The problem of erosion frequently appears in connection with convective rain storms.

Combined Sewer Overflow (CSO)

Old urban areas are usually drained by combined sewer systems. When the capacity of the system is exceeded, volumes of untreated water overflow the system and are discharged directly to the recipient. This usually happens in connection with convective rainstorms or heavy snowmelt. Fig. 6 gives measured ratios between CSO and normal river flow. CSO can also occur during dry periods due to plugging of the overflows and sewers. This type of CSO is especially serious because of the absence of diluting rainwater.

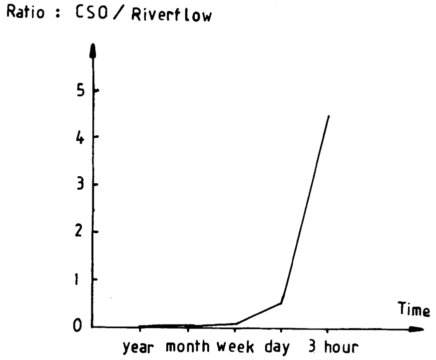


Fig. 6. Ratio between CSO and the natural river flow for different time-scales.

Quality of Discharge

The effects of pollution due to urban discharge on the receiving waters can roughly be divided into two types: long-term and short-term effects. The long-term effects, eutrophication, are estimated on the basis of long-term qualitative waterbudgets. However, the long-term loads tell very little about the toxic risk for the receiving waters. The effects of pollution created by stormwater discharge and CSO, appear during much shorter periods. By analysing pollutographs (concentration of pollutant versus time) and use of appropriate knowledge from ecological response of quality changes in the water, it is possible to obtain a reasonable picture of the short term effects.

During quality sampling, it is important to make the time interval between samples short enough in order to consider the rapid variation in concentration of pollutants during the early phase of the runoff. The short term effects are related to separate pollutographs, while long term effects are the integrated effect of every pollutional event during an observed period.

In order to further analyse these problems and to determine the most dangerous kinds of urban discharge for southern Swedish recipients, a number of qualitative measurements were performed in Lund. (Hogland et al. 1982). Pollutographs for different types of precipitation and urban discharge were measured.

Storm Water

During high-intensity rainfall events, a first-flush effect can usually be observed. First-flush is defined as the phenomenon in which the most contaminated stormwater discharge occurs at the beginning of a significant runoff event. The first-flush phenomenon originates from a number of different sources including pollutant accumulation on the drainage area, catch basin deposition, roof top accumulation and sewer solid deposition. The accumulation rate of the pollutants varies depending on landuse and population density. The exact location in time of the concentration peak is difficult to predict, but it normally occurs immediately before the hydrograph peak.

Fig. 7 shows a comparison of measured pollutographs for precipitation with different intensities.

The two pollutographs represent contaminated runoff due to a small precipitation event (~ 2 mm) and a frontal precipitation event (~ 17 mm). The urban area contributing to runoff consists mainly of residential housing with small commercial centres and local industries. The two pollutographs differ mainly for suspended solids (Susp) and the heavy metal zinc (Zn). For the frontal precipitation event the short time effects are more pronounced for these pollutants.

Since heavy convective rainstorms appear during the summer, when the river-flow is low, toxic shock-effects on the aquatic life are likely to occur. If these situations coincide with the most sensitive reproductive phases of organisms in the

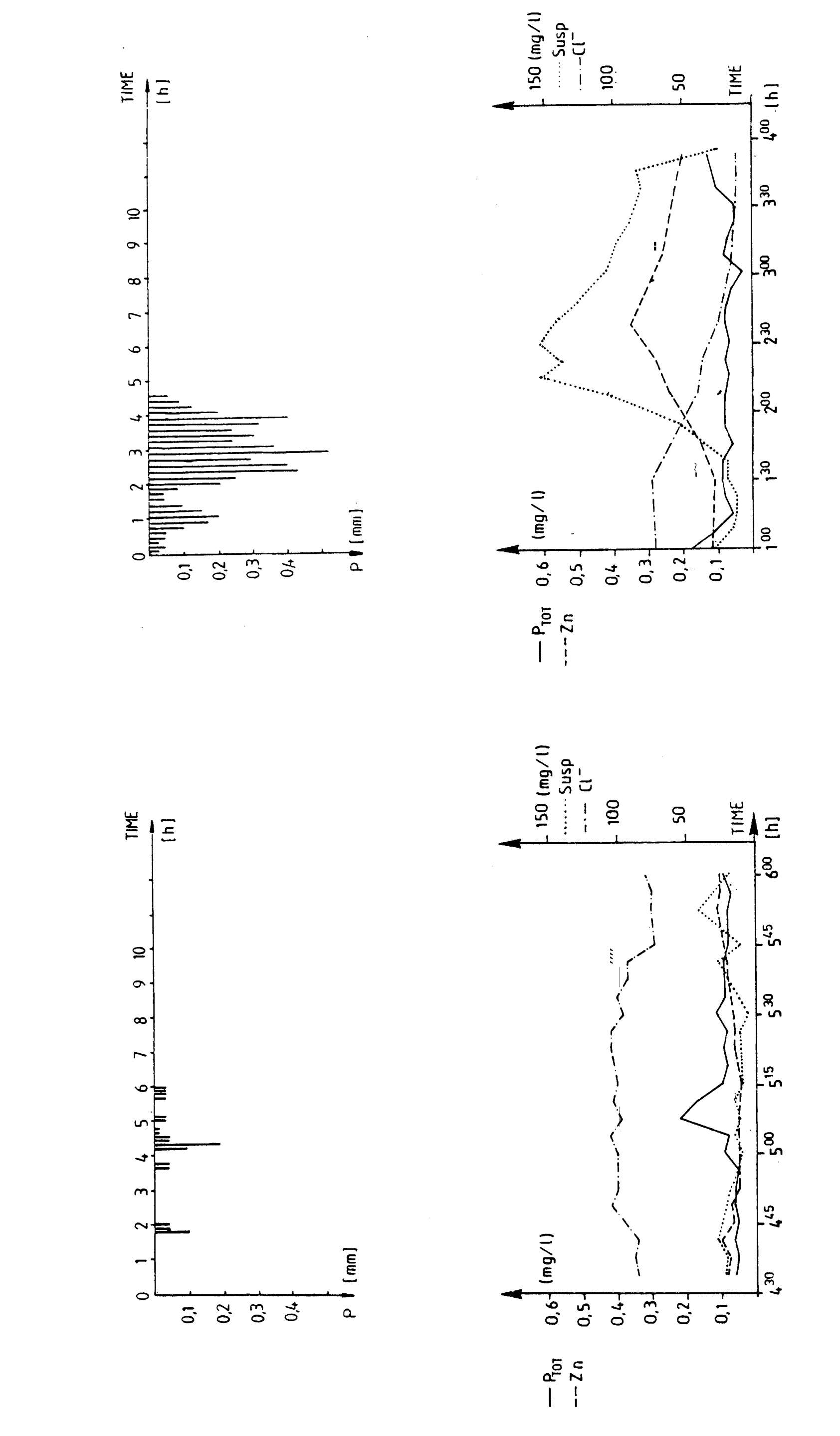


Fig. 7. Pollutographs of the stormwater from two different types of precipitation (Hogland et al. 1982).

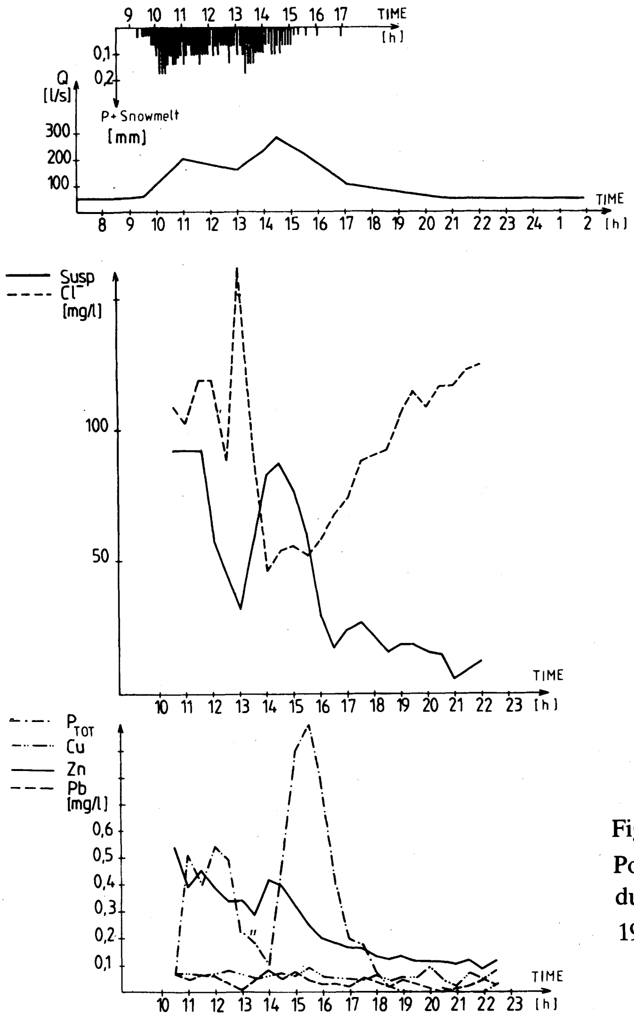


Fig. 8.
Pollutographs of the stormwater during snowmelt (Hogland et al. 1982).

receiving water serious disturbances in the ecological conditions are to be expected.

Snowmelt

For the previously mentioned area, pollutographs from snowmelt have been measured. Fig. 8 shows that very high concentrations of pollutants are to be expected during short time periods in conjunction with snowmelt. Periodically, the concentrations of zinc and phosphorus are many times higher than those in Fig. 7.

This polluted discharge may, however, not make a very serious effect on the biological conditions in the river because of the usually high natural riverflow during springtime.

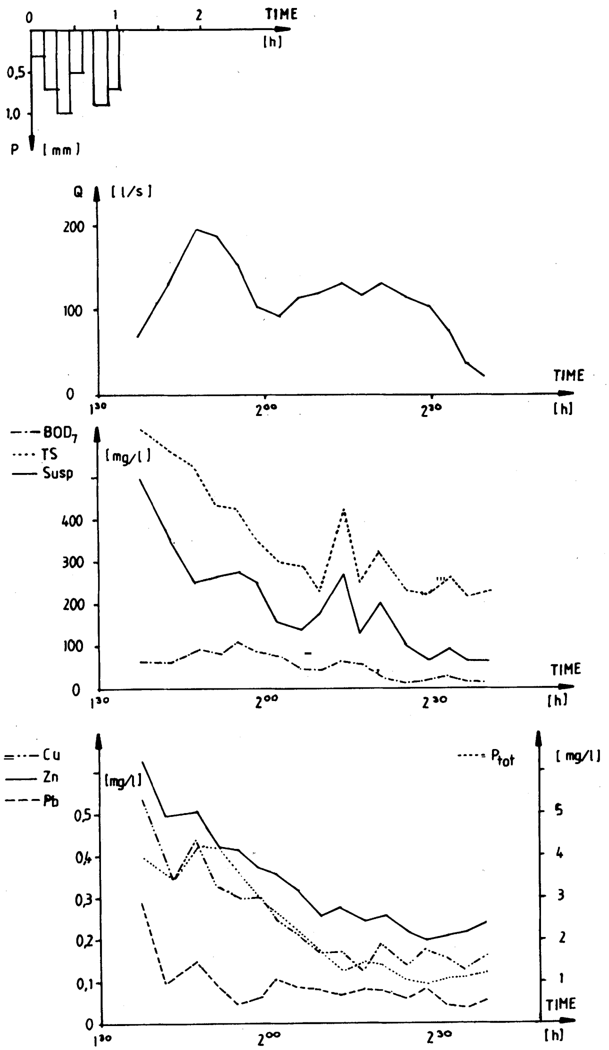


Fig. 9.
Pollutographs measured at weir during a CSO event (Hogland et al. 1983).

CSO

Fig. 9 shows pollutographs from a CSO event. This type of discharge combines the typical pollution sources of stormwater and untreated wastewater. Phosphorus and nitrogen originate from the sanitary sewage while high concentrations of heavy metals are associated with the urban stormwater.

CSO discharge has probably the most serious effect on the recipient, especially if it occurs during summer. The frequence of CSO is highest during June to August in Sweden due to heavy convective rainstorms (Hogland et al. 1983). These often coincide with very low natural riverflow. This means that the contaminated discharge will probably have a greater impact on the organisms in the recipient.

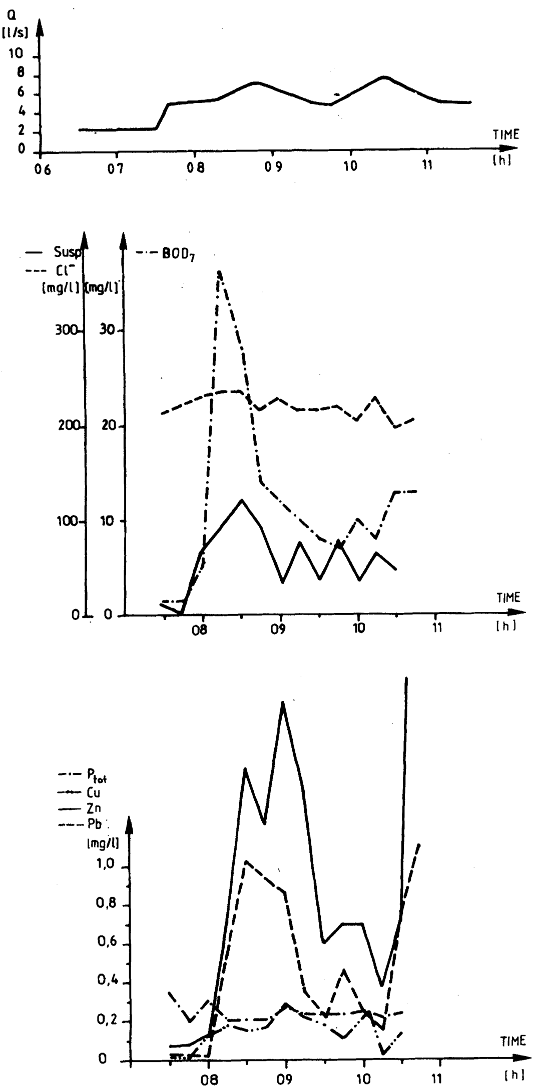


Fig. 10.
Pollutographs of storm water during industrial discharge.

Industrial Dicharge

Finally a source of pollution not always payed attention to is discharge into the stormwater systems from areas with special land use, for example local industries. Fig. 10 shows pollutographs originating from daily industrial discharges.

Periodically extremely high values of heavy metals (Zn, Pb) were found. This kind of discharge can have a very serious effect on the receiving waters during dry periods and when the discharge is large.

Discussion

In the southwest of Sweden a common type of recipients for urban discharge is small rivers and creeks. Due to large variations in flow of these recipients, the polluted discharge can have different effects on the aquatic life. The most critical periods often occur during summer. This is due to the normally very low river flow during summer and the heavy rainstorms which flushes gutters and sewage pipes of pollutants and also may cause combined sewer overflows.

By analysing pollutographs and use appropriate ecological data it is possible to obtain a reasonable picture of short term toxic effects on recipients. For this, the ratio between discharged polluted water and riverflow must be taken into account.

Variations in pollution concentrations often occur within short time-periods. High concentrations in urban storm water can usually be traced to local pollution-sources. In Table 1 examples of extreme values of different pollutants in urban storm water from Lund are shown.

Table 1 – Maximum of pollution-concentrations in urban stormwater in Lund (mg/1)

Susp	TS	FS	BOD_7	Cl-	P_{tot}	Cu	Zn	Pb
540	1940	1800	150	920	12,8	4,3	4,6	1,1

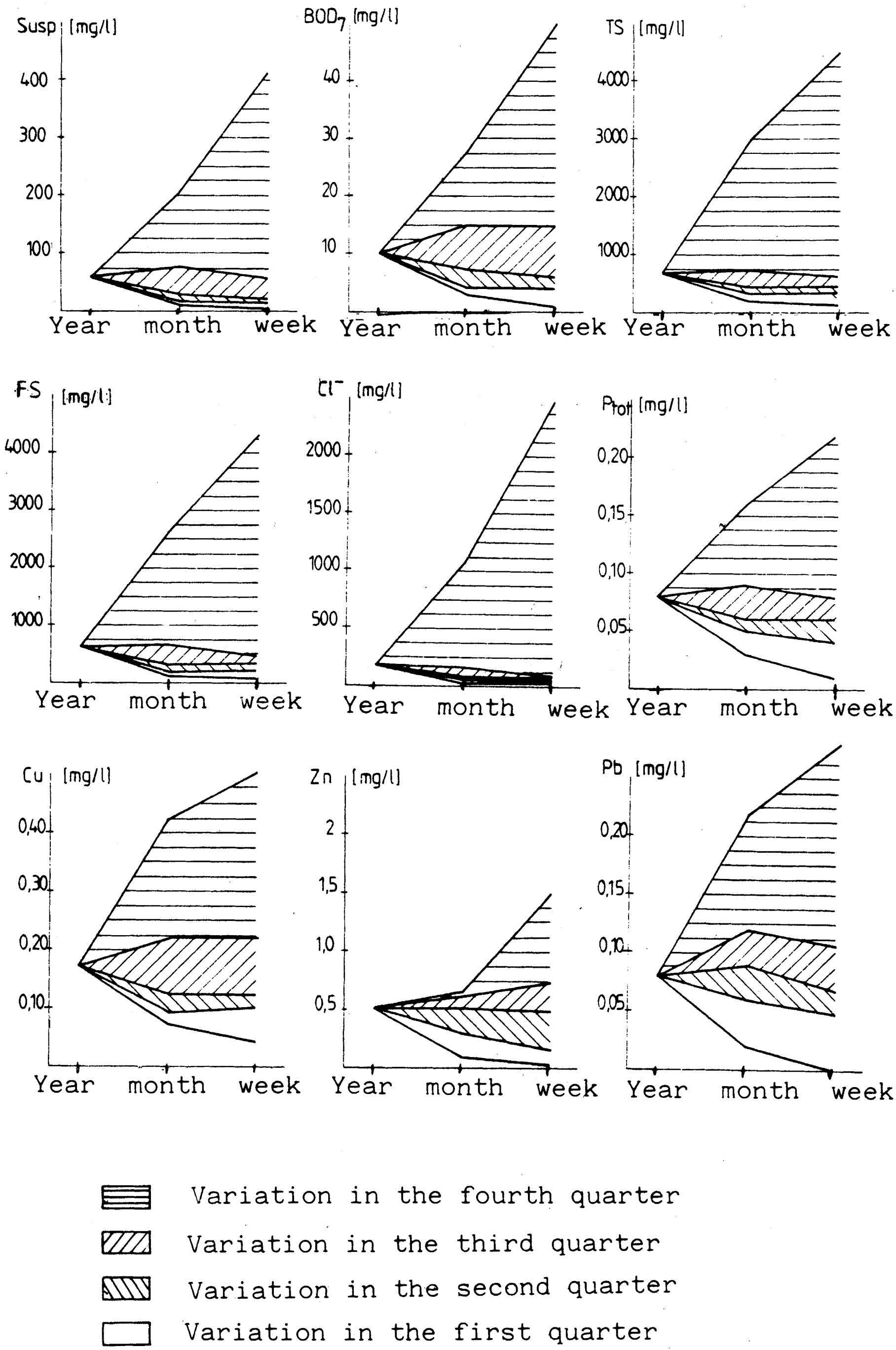
These pollutants could be traced to different types of sources. For instance the high phosphorous-concentration was due to overflow. The high copper and zinc concentrations were found in areas with corroding copper and zinc roofs etc.

On basis of measurements in urban stormwater in Lund during 17 months (weekly flow-proportional, Hogland et al. 1979, 1980) Fig. 11 was drawn.

Fig. 11 was constructed by dividing all series of mean values into quarters (after arranging the mean values from low to high). The variation in mean values for year, month and week are presented. The figure shows that extreme concentrations usually are rare (see for example Cl-). Usually 75 % of all analysed concentrations are gathered round a narrow interval. When concentration values are found in the range of the fourth quarter, this is likely to be caused by a local pollution source. For example high concentrations of phosphorous can be caused by plugging of the combined sewer system. Depending on which type of pollutants occurring it is possible to suspect a certain kind og pollution source.

Fig. 11 can be used as an indicator for random-samples. When the analysed sample falls within the upper quarter there are reasons to suspect local pollution sources and further investigation should be made.

Fig. 11. Analysis in Lund of concentrations of contaminants in the stormwater depending on sampling period.


Susp [mg/l]
400
300
200
100
BOD_7 [mg/l]
40
30
20
10
TS [mg/l]
4000
3000
2000
1000
FS [mg/l]
4000
3000
2000
1000
Cl^- [mg/l]
2000
1500
1000
500
P_{tot} [mg/l]
0,20
0,15
0,10
0,05
Cu [mg/l]
0,40
0,30
0,20
0,10
Zn [mg/l]
2
1,5
1,0
0,5
Pb [mg/l]
0,20
0,15
0,10
0,05
Year
month
week
Variation in the fourth quarter
Variation in the third quarter
Variation in the second quarter
Variation in the first quarter

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