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VARIATION OF DISSOLVED MATERIAL CONCENTRATION DURING STORM EVENT IN A SMALL WATERSHED

MICHA KLEIN
University of Haifa, Israel

INTRODUCTION

In the analysis of dissolved material concentration — discharge relationship, the use of the dilution model is common. The dilution model explaining the solute transport is usually based on data derived from various samples which are characterized by low frequency of sampling. The range of frequencies covers infrequent samples on a monthly, weekly or daily basis. Therefore, the usual rating curve of dissolved material concentration — discharge relationship ignores the condition of flow (rising or falling stage, low or high base flow) at the time of sampling.

Data from recent higher frequency events raises a question as to whether the simple model is suitable for explaining solute transportation during storm events. The dilution model cannot explain the flushing effect which has been mentioned in recent papers (Walling, 1974, 1975; Walling and Foster, 1975). The flushing effect has to be ignored when using the dilution model because the latter model is based on low frequency samples. If the flushing effect is to be investigated, one or more variables should be intensively sampled throughout a large variety of events.

Thus, specific electrical conductance has been accepted as an appropirate measure of the total solute content of the sampled water, since a general relationship between conductivity and total dissolved solutes has been established (Edwards, McDonald and Petch 1975). The general relationship between the two is: T.D.S = KEC where TDS — denotes Total Dissolved Sulute in p.p.m. K is constant, normally varying in the range 0.6 — 0.75, and EC denotes specific electrical conductivity in μmhos/cm (Edwards, McDonald and Petch,

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1975). Conductivity can provide valuable information whithout laboratory work. For this purpose a detailed study of the flushing effect in a small catchment was carried out in the Holbeck basin in Yorkshire.

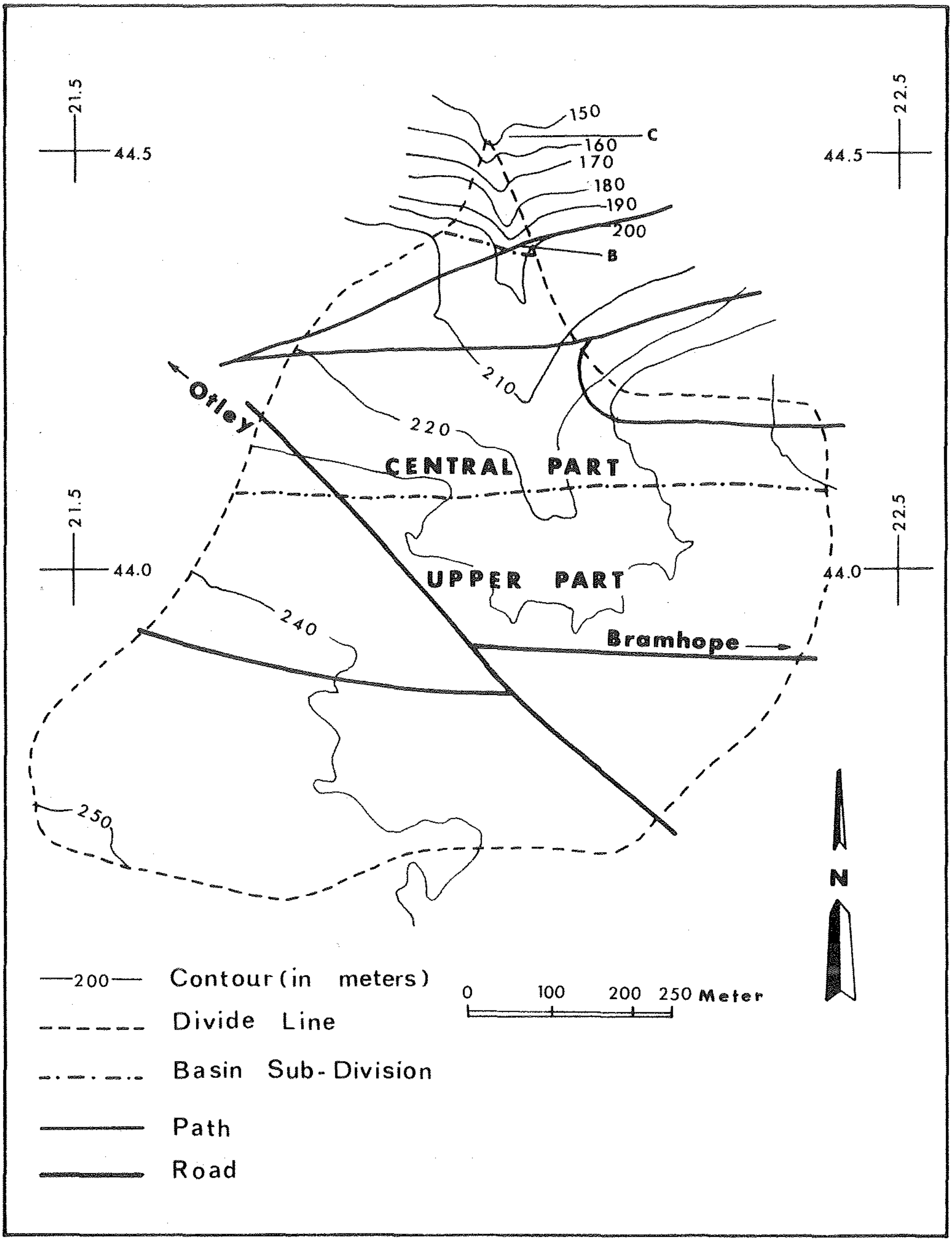

Fig. 1: The Holbec catchment.

THE HOLBECK CATCHMENT

The Holbeck channel Grid Ref: NS 220440 (Fig. 1) is the only channel which cuts the Otley escarpment and drains the Otley Chevin into the river Wharfe. The Otley escarpment is seven km. long and the Holbenk catchment is located in an area where the distance from the top of the escarpment to the divide is the greatest; hence the drainage area is large enough to support a channel. The upper part of the basin is covered by till and the vegetation in this part is pasture grassland. The slopes are low and the drainage is mainly through artificial field tile drainage. The central part of the basin down to the waterfall — point B is covered by the till formation, the slopes are steeper and the vegetation is Scrub Birch, Rowan, Bracken, Heather Grasses. This part of the catchment is drained mainly by open ditches. The lower part of the basin from the waterfall to the measurement station — point C consists of the Millstone Grit series — (which held the escarpment and the waterfall). The slopes are very steep — up to 60° — and the vegetation is Mature Birch, Sycamore, Bracken, Heather Grasses. The average annual rainfall in the area is 700 mm. and the average number of rainy days per year is 140. The area of the studied catchment is about 0.5 km_2.

FIELD METHODOLOGY

A 90° 'V' notch weir was installed at the measuring site to enable measurement of discharge, but it was not possible to install a continous stage recorder. Discharge measurements were made mainly during flood events by measuring the water level in the 'V' notch and converting the water level to discharge using a conversion table. The interval between stage measurement was 1—5 minutes, on the rising limb of the hydrograph at the peak, whereas during the recession limb the interval was 10—15 minutes. During storm events water samples were taken at the weir. The interval was similar to the one for stage measurements, i.e., 1—5 minutes during the rising limb and the hydrograph peak and 15—30 minutes during the recession limb. The conductivity of the water samples was measured in the field using a conductivity bridge within two hours of sampling time.

The rain was measured by a rain collector installed near the 'V' notch. During rain events the collector was checked every 15 minutes; thus the rain intensity for 15 minute time units is known. The nearest permanent rain gage is less than 1 km. away from the 'V' notch at Otley sewage works. The data obtained from this station was on the whole very similar to the data obtained in the Holbeck basin.

RESULTS AND DISCUSSION

A study of channel flow conductivity during storm events indicates the following patterns of discharge — conductivity relationship. About 30 flow events were observed during the 18 months in which the field work was carried out. The typical patterns are represented by the following events.

1. A summer event which follows a dry period is characterized by flushing (Fig. 2). In summer the decayed material tends to accumulate mainly at the bottom of the slopes and in the channel. As both the flow velocity and the water turbulence are low, the decayed material accumulates mainly in the channel banks and in the channel pools. When flow velocity and turbulence increase during a storm event, the dissolved material is washed out and causes a rise in the water conductivity. However, the dilution does influence

the dissolved material concentration — discharge relationship in the second stage of the event. The high peak in water conductivity is followed by a decrease, due to dilution, to a minimum conductivity.

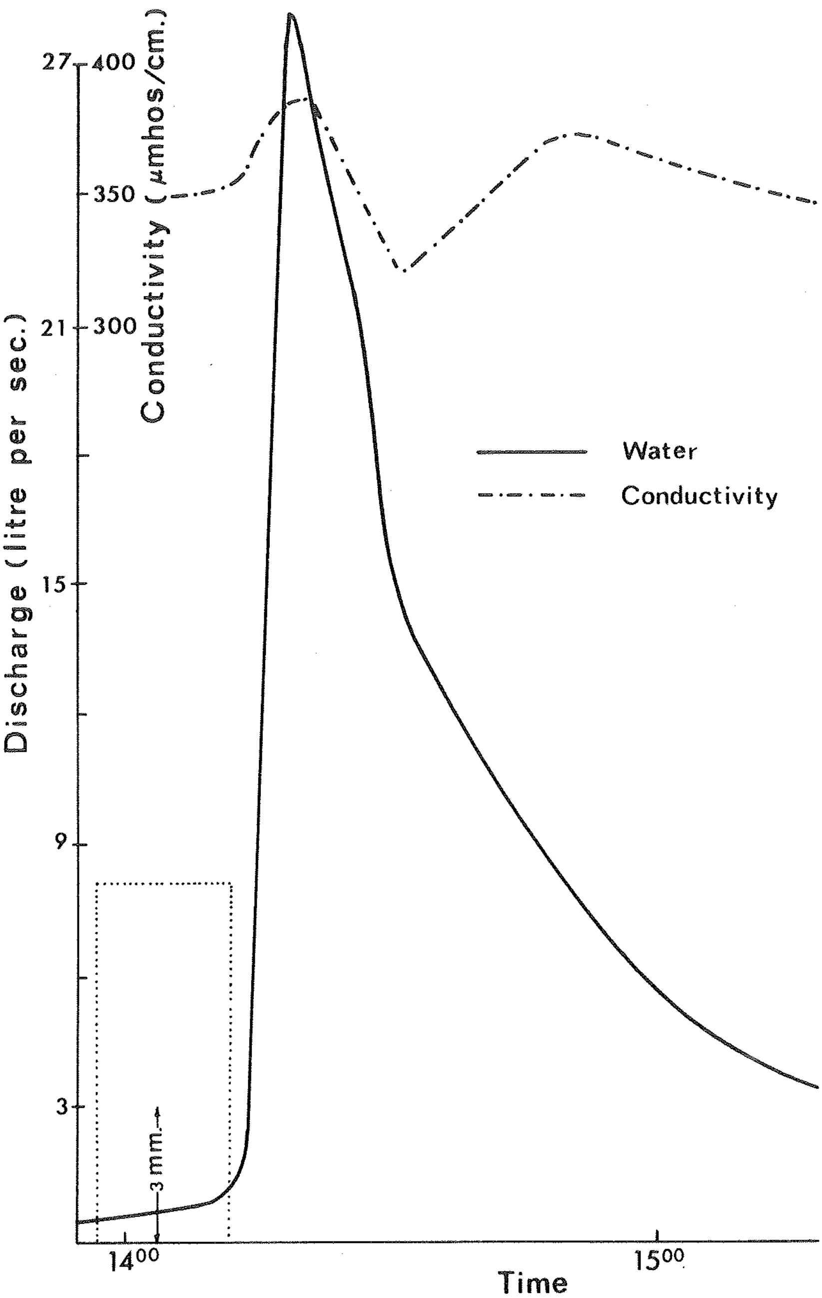

Fig. 2: The event of 23.5.1974; notice the flush in conductivity during the hydrographic peak.

2. A summer event which follows a wet period has no flushing effect and the expected pattern of decrease in conductivity as the discharge increases is verified by observation (Fig. 3). A summer event which occurs shortly after a previous event does not allow any accumulation of decayed material, hence the conductivity does not rise.
3. A winter storm with a slow rising hydrograph has an advanced peak of conductivity (Fig. 4). In winter the high base flow does not allow accumulation of dissolved material in the channel itself. Dissolved material

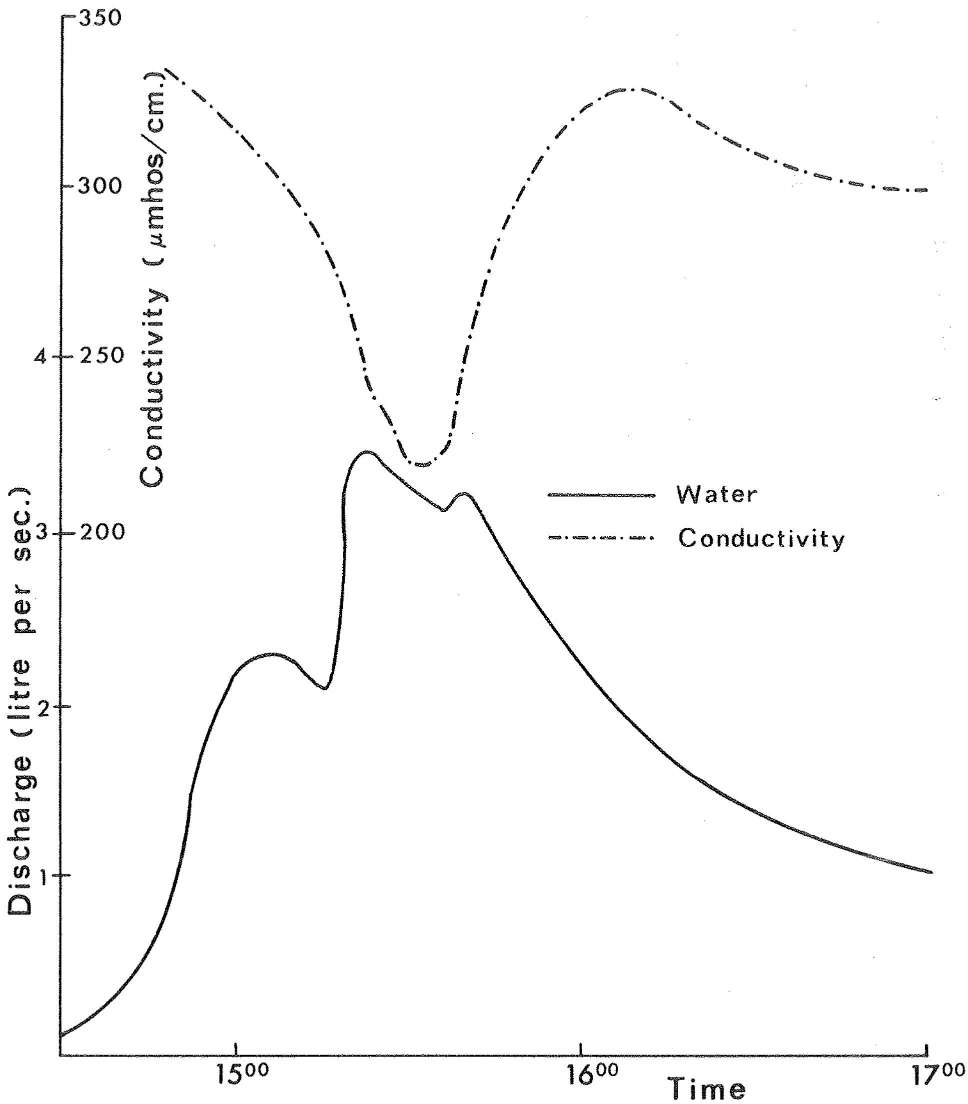

Fig. 3: The event of 19. 8. 1974; notice the decreasing conductivity during the hydrographic peak.

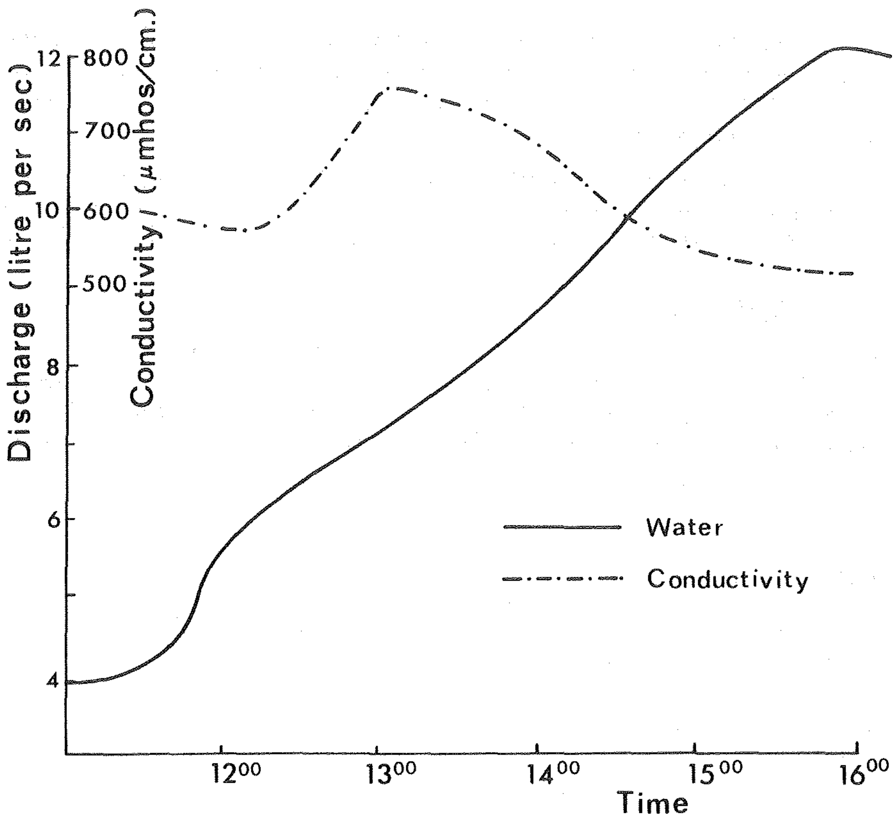

Fig. 4: The event of 21.11.1974; notice the peak in conductivity in the early stage of the event.

accumulates instead in small ponds along the 'micro' flood plain. The slowly rising hydrograph and because these ponds are washed out at the early stage of the event causes the conductivity peak to precede the hydrograph peak. In order to show the existence of high conductivity water in the flood plain ponds in a wintry high base flow, samples were taken simultaneously from the channel and from the ponds at two different points: one in the lower part of the basin and one in the central part. The samples were taken during

Table 1: Results of pond conductivity and the associated channel conductivity (μmhos/cm).

	central part		lower part	
Date	Channel	Pond	Channel	Pond
3.1.1975	280	309		
6.1.1975	290	331	269	275
9.1.1975	288	332	261	281
14.1.1975	295	328	281	340

high base flow following a number of days without heavy rain a situation which would have caused some replacement of the water in the ponds (Table 1). The water conductivity in the ponds is about 10% — 15% higher than the channel conductivity.

To sum up, it could be argued that a study of conductivity — discharge relationship for the early stages of an event has to take into account the number of days since the last heavy rain event. Heavy rain can be defined either by rain intensity parameter or by the amount of rainfall.

CONCLUSIONS

The flushing effect plays an important role in small basins in which the stream flow is fed by quick response source such as channel precipitation or overland flow and therefore tends to wash away rapidly all the available material. Flushing appears to be a function of accumulation of decayed material in a vegetated area such as the Holbeck basin.

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