Biological environments of larger UK Rivers: third progress report.

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(DoE Contract: PECD 7/7/200)

Third progress Report; November 1988

1. CONTRACT DETAILS

Start date: 20 June 1986

Completion date: 31 May 1989

Percentage time elapsed: 80%

Contract Sum : £165 000

DoE Contract, not formalised; equivalent to 35% cost.

Staff employed during period

Grade	Number	Effort
SPSO	1	10 months
SSO	1	10 months
SO	1	10 months

Items of Capital Equipment

Item	
'Aquatracka'	£17 000

2. Objectives of Project. The conceptual basis of the present work was founded upon the contention (i) that hitherto-accepted models of fluvial flow are inappropriate for the estimation of dispersion rates of entrained solutes and particulate loads and (ii) that the existence of viable, self-replicating phytoplankton in rivers was paradoxical without the simultaneous and widespread existence in those rivers of physical mechanisms for retaining significant volumes of water against the general discharge (1, 2). The single, aggregated dead-zone- (or ADZ-) model (3) provided practical evidence that the ADZ-concept might furnish an important basis for the investigation of (i) and (ii) above: as viable, growing respondents of the physical environment of larger rivers, the dynamics of natural phytoplankton populations ought to furnish useful markers of the

spatial- and short-term temporal- variability of the fluvial flow. The project was conceived to provide insights into the mechanisms by which populations of particles (in this instance, phytoplankton) behave in relation to fluvial flow and, thus, to better model the dispersive properties of rivers and the ecological principles governing the distribution of potamoplankton generally.

3. Progress in Period. Very significant progress has been made during 1988; definitive summaries of the various components of the work can be offered.

3.1 Verification of dead-zone 'presence' 'Conventional' dye-tracing has continued to be applied to the study reaches under what is now a wide range of discharges (9 – 240 m^3s^{-1}): 'retention' is always active and ADZ-calculation always accounts for 25-40% of reach volume. Several tangible storage zones have been identified on the ground and are known to have persisted continuously since their 'discovery', a period during which there were two major flood events (October 1987; January 1988).

3.2 Detection of dead zones. At most times of the year, water in storage zones contains the hypothesised higher concentration of algae. A further example is given here (Fig. 1) which shows the fluorescence distribution over a section of the 'downstream pool' study reach at Montford Bridge ('MONTFORD DP') taken under discharge conditions of about 65 m^3s^{-1} and only one week later than the seasonal peak of 240 m^3s^{-1}. The gradient in algal chlorophyll between the 'dead'- and the flowing-water is (2/1.45 =) 40%. Earlier differences of 100% have been reported for the same section. Assuming some difference in chlorophyll concentration to be characteristic, remote sensing by NERC was commissioned. Two separate overflights were made of the Leighton Park study area, in May and in August. Not only were areas of the river channel clearly distinguishable by colour imagery in Band 3 (chlorophyll zone) and Band 11 (long-wave thermal reflection, indicating localised warming of non-flowing surface) but one in particular was remarkably intense. Ground-truth sampling has established that a major part of the chlorophyll reflectance _is_ due to _planktonic algae_ and not to bottom reflectance: peak concentration 217 against 6 mg m^{-3}, ambient in the open flow.

3.3 _Dead-zone dynamics_. One dead zone has been studied in detail during May 1988 in order to calculate the rates of fluid exchange (about 2% h^{-1}). A half-life in the order of 1 d should be sufficient to explain the 1.5-2 fold differences in chlorophyll concentration inside and outside the dead zone. The Leighton Park dead zone had a 40-fold gradient in _suspended_ chlorophyll which was distinguished in terms of species composition (it was actually dominated by a slow-growing alga) which would have required 35-50 days isolation to differentiate: (exchange $\sim$0.1% h^{-1}). This is a remarkable discovery: part of a clearly defined river channel but sheltered by a promontory behaves like an isolated pond.

Even if we assume that each dead zone has its own dynamics, this poverty of fluid exchange is quite remarkable. Reach retention may be underestimated by the dye-tracer method.

3.4 _Phytoplankton dynamics_. Monthly sampling down the Upper Severn from the headwaters to Ironbridge, has shown that (i) the plankton is ever present; that the species in middle reaches are typically those of rivers but they are not the remnants of limnoplankton of the upper catchment area, which only dominate the headwaters (ii) that quantity and species composition is discharge-sensitive (diatoms are generally more tolerant of silt loads and compete well with green algae in the middle reaches, except during low flows, when green algae become prominent). Moreover, (iii) modelling of specific dynamics have been used regularly to calculate travel times between two fixed points. In every instance, the modelled growth at the mean fluvial velocity is about one third to one half that actually attained. This original "paradox" (described in 4) seems to be wholly attributable to plankton growth in dead zones.

4. Outline plans (for next 6 months). A great deal of data analysis and collation of material is required to be undertaken, in preparation for the production of the final report.

5. Dissemination of information. The literature review has been published (Ref 4); the suspension/depth/velocity-study manuscript has been completed but has not yet been submitted for publication. No other external presentation of these results has been made.

6. References

(1) Freshwater Biological Association (1986). Progress Report, Biological environments of larger UK rivers, April-December 1986.

(2) Water Authorities Association (1986). Water pollution from farm waste. W.A.A., London (see esp. p. 13).

(3) Young, P.C. & Wallis, S.G. (1987). The aggregated dead-zone model for dispersion in rivers. Proceedings of the Conference on Water Quality Modelling in the inland natural environment, pp. 421-433. BHRA, Cranfield.

(4) Reynolds, C.S. (1988). Potamoplankton: paradigms, paradoxes and prognoses. In: Round, F.E. (ed.) Algae and the aquatic environment, pp. 285-311. Biopress, Bristol.