University College Cork

Workshop

“Ecological responses of streams to nutrient enrichment“

Cork,
February 23-2[illegible]009

Time	Monday, Feb 23rd
	Introduction
9:30	**Marcel Jansen (University College Cork, Ireland)**
9:40	**Alice Wemaere (EPA, Ireland)**
10:00	**Martin McGarrigle (EPA, Ireland)** *"Irish streams and pollution history"*
10:40	**COFFEE BREAK**
	Nutrient enrichment in streams
11:20	**Christian Dang (University College Cork, Ireland)** *"Benthic algae and nutrient enrichment"*
12:00	**Nigel Willby (University of Stirling, UK)** *"Macrophytes and nutrient enrichment"*
12:40	**LUNCH BREAK**
13:40	**Conor Graham (University College Cork, Ireland)** *"Fish and nutrient enrichment"*
14:20	**Mark Gessner (Eawag/ETHZ, Switzerland)** *"Leaf decomposition and nutrient enrichment"*
15:00	**Mary Kelly Quinn (University College Dublin, Ireland)** *"Experimental manipulation of nutrient enrichment"*
15:40	**COFFEE BREAK**
16:20	**Michael Sturt (University College Cork, Ireland)** *"Grazing and nutrient enrichment"*
17:00	**Gabriel Singer (University of Vienna, Austria)** *" Invertebrate and nutrient enrichment"*

Time	Tuesday, Feb 24th
	Monitoring and remediation
9:00	**Sergi Sabater (University of Girona, Spain)** *"Remediation of nutrient enrichment by stream functions"*
9:40	**John Lucey (EPA, Ireland)** *"Monitoring nutrient enrichment with macroinvertebrates"*
10:20	**COFFEE BREAK**
11:00	**Martyn Kelly (Bowburn Consultancy, UK)** *"Monitoring nutrient enrichment with diatoms"*
11:20	**Chris Mainstone (Natural England, UK)** *"Applied aspects of stream eutrophication"*
12:00	**LUNCH BREAK**
13:00	**ROUNDTABLE DISCUSSION**
15:00	**COFFEE BREAK for Steering Committee**
15:30	**IMPLANT STEERING COMMITTEE**

ACCUMULATION OF PERIPHYTIC BIOMASS IS NOT DIRECTLY CORRELATED WITH NUTRIENT LEVELS IN IRISH STREAMS

Christian K. Dang, Michael M. Sturt, Marcel A.K. Jansen and Simon Harrison

Department of Zoology, Ecology and Plant Sciences, University College Cork, Enterprise Centre, North Mall, Cork, Ireland

Abstract:
Nutrient enrichment threatens freshwater ecosystems worldwide. Yet, there is still a remarkable lack of knowledge on the ecological consequences of nutrient enrichment in streams. Such knowledge is urgently required to establish nutrient criteria, particularly in those many regions of the world where pristine streams are under threat of human development. We have studied periphyton accumulation and macro-invertebrate communities in summer, autumn and spring in 32 streams [ranges of nutrients: 0-0.55mgP/L and 0-10mgN/L]. There were no seasonal differences in stream nutrient status, *i.e.* a stream that had low nutrients at one season had also low nutrients at the other two seasons and *vice versa*. The relationships between nutrients and periphyton were best described by filled "humped"-shape curves. The decrease of Chl *a* at higher nutrients in summer was strongly correlated with increased biomass of specific grazers (*e.g. Baetidae*), suggesting top-down regulation of primary production. Thus, contrary to our expectation higher nutrient levels did not elicit higher algal biomass, but apparently higher grazing pressure. Our results question whether Chl *a* level is a suitable parameter to determine trophic status of streams.

MACROPHYTES AND NUTRIENT ENRICHMENT

Nigel Willby

University of Stirling, UK

Abstract:
Fluvial-geomorphology defines the habitat template for river macrophytes, with hydraulic forces and flow variability providing the over riding determinants of abundance and composition. Nutrient availability is an important, but secondary factor that can modify the response of macrophytes to key physical constraints, for example, increasing the rate of recovery after disturbance, or increasing the risk of wash-out due to accelerated growth and increased drag. The evidence for predictable responses of macrophytes in rivers to nutrient enrichment is assessed using large scale datasets for UK rivers, and the problem of partitioning an anthropogenic signal from the background productivity gradient is discussed. The response of macrophytes to nutrient enrichment in rivers is greatly dampened compared to that seen in lakes. Thus there is little evidence of a predictable change in taxa richness in relation to nutrient concentrations. Compositional changes continue to occur in river macrophyte assemblages at P concentrations that are an order of magnitude higher than those found in lakes when compositional changes cease. River macrophytes retain a degree of functionality at nutrient concentrations where phytoplankton would have long replaced macrophytes in lakes. Nevertheless, nutrients do exert a significant independent effect on both composition and abundance, providing various opportunities to utilise macrophytes for biomonitoring purposes. Within this context it is important not to confuse the prediction of phosphorus concentrations with the detection of eutrophication. Possible biological mechanisms behind the response of macrophytes to nutrients are described and nutrient standards that support river macrophytes at good ecological status are presented.

THE EFFECT OF NUTRIENT ENRICHMENT ON SYMPATRIC ATLANTIC SALMON (*SALMO SALAR L.*) AND BROWN TROUT (*S. SALAR L.*) IN COLD AND WET IRELAND

Conor Graham, Simon Harrison and Paul Giller

Department of Zoology, Ecology and Plant Sciences, University College Cork, Enterprise Centre, North Mall, Cork, Ireland

Abstract:
Eutrophication can have many deleterious effects on running waters, the most obvious of which is the great increase in algae and macrophyte abundance and increase in benthic organic matter. The respiration of plants and subsequent organic matter decay of these can then lead to widespread and ecologically damaging stream anoxia. Salmonids, in particular the eggs and younger life stages, have only weak tolerance to low oxygen concentrations and are therefore particularly vulnerable to organic pollution. Ireland has a mild and wet maritime climate, resulting in cool riverine water temperatures and relatively high flows in summer, and as a consequence, constantly high dissolved oxygen levels. Trophic enrichment, rather than anoxic effects, is likely to be a more important process. We present results of the impact of such trophic enrichment on sympatric salmon and trout populations in seven southwestern Irish streams over a gradient of phosphorus. We found that salmon are more abundant in medium-low nutrient streams whereas trout densities increase with instream nutrients. The growth of salmon is greatest at medium nutrient levels whereas trout growth increases positively with enrichment. Salmon production is very high at mid nutrient levels but is significantly reduced with increasing trout density and production at higher nutrient levels. We conclude that increasing food availability through increasing primary and hence, secondary production, allows salmon and trout to increase their abundance, growth and production with rising nutrient levels. However, whereas the more efficient foraging salmon can respond positively at more moderate nutrient levels, the socially dominant but less efficient foraging trout exclude the salmon through interference competition.

EFFECTS OF DISSOLVED NUTRIENTS ON PLANT LITTER DECOMPOSITION: AN APPRAISAL OF NEW AND PUBLISHED DATA

Mark O. Gessner

Eawag, Dubendorf, Switzerland

Abstract:
Effects of dissolved nutrients on autotrophic processes have long been a cornerstone of aquatic ecosystems ecology and management. Heterotrophic processes have received much less attention, although processes such as litter decomposition may be even more important for overall system functioning than primary production particularly in many benthic aquatic systems. Nutrient enrichment experiments in a range of experimental settings have clearly demonstrated the sensitivity of litter decomposition to both N and P supply, mediated by microbial decomposers and/or litter-consuming detritivores. Threshold concentrations of dissolved nutrients beyond which no further stimulation of decomposition is detected are low (*e.g.* 200 µg N/l) compared to concentrations measured in most regions of the world where cultural eutrophication has occurred. This together with the multitude of other factors influencing decomposition rate explains why clear responses to dissolved nutrient supply are not always seen in broad-scale surveys. Experiments in streams suggest that dissolved nutrient concentrations may not only control decomposition rates per se but that they are also instrumental in shifting the relative importance of litter nutrient concentrations vs carbon quality in determining litter decomposability. Most effects on decomposition in nutrient enrichment experiments have been positive. However, there is evidence also for negative effects of nitrogen supply, similar to findings in terrestrial environments, and this inhibitory effect could be exacerbated under global warming. The underlying mechanisms are poorly understood, however. Unraveling the intricacies of dissolved nutrient effects, both positive and negative, at a mechanistic level remains a major challenge towards fully understanding controls of decomposition rates in ecosystems.

EXPERIMENTAL ENRICHMENT OF A HIGH STATUS RIVER IN THE WEST OF IRELAND: EFFECTS OF NUTRIENT MANIPULATION ON THE GENUS *ECDYONURUS* AND BENTHIC CHLOROPHYLL LEVELS.

Aisling Walsh[1], Martin McGarrigle[1] and Mary Kelly-Quinn[2]

[1]*Environmental Protection Agency;*
[2]*School of Biology & Environmental Science, University College Dublin.*

Abstract:
The effects of eutrophication on *Ecdyonurus* were studied using a novel split-stream experiment which involved artificially increasing the phosphorus concentrations in two oligotrophic rivers in the West of Ireland. Chlorophyll levels were measured along the length of the experimental and control stretches over a period of 5 to 8 weeks. Quantitative sampling of macroinvertebrates was undertaken on several occasions during the experimental period. Some of the nutrient manipulation experiments showed significant differences in algal biomass between the control and treated sections, but not all did so. No effect on the abundance of *Ecdyonurus* was detected. The experiments did reveal surprising results suggesting the importance of N-limitation in the rivers studied. Analysis of the N:P ratios in a number of 99 rivers in the west of Ireland found that approximately 4% of the samples were N-limited with low MRP concentrations (<0.05mg/l P). This implies that a small proportion of high status rivers are N-limited rather than P-limited. Overall, the results from these studies highlight the complexity of in-stream processes and likely responses to eutrophication.

ACCUMULATION OF EXCESSIVE ALGAL GROWTH IS MITIGATED BY BOTH GRAZING BENTHIC MACRO-INVERTEBRATES AND SHADE OF THE RIPARIAN CANOPY

Michael M. Sturt, Marcel A.K. Jansen and Simon Harrison

Department of Zoology, Ecology and Plant Sciences, University College Cork, Enterprise Centre, North Mall, Cork, Ireland

Abstract:

The density of in-stream grazers (periphyton-feeding benthic macro-invertebrates) was manipulated in the Owennagearagh River, County Cork, Ireland to study the ability of grazers and riparian vegetation shade to mitigate nutrient mediated nuisance algal growth. A number of both heavily shaded sites and open sites, upstream and downstream of a nutrient point source were selected for these manipulation experiments. The density of grazing invertebrates accessing pre-conditioned unglazed ceramic tiles was reduced using high voltage pulses (grazer exclusion) compared to non-electrified control tiles. Grazer excluded and control tiles were deployed in shaded (>80% canopy cover) as well as open sites (<16% canopy cover) at three distinct stretches of the stream, characterised by varying nutrient levels. The macro-alga *Cladophora glomerata* was present on naturally occurring substrata in all three sites. Dissolved oxygen concentrations and stream substrate redox potentials showed no evidence of anoxia. Following 15 days of submergence in the stream, *Cladophora* cover, periphytic chlorophyll-*a* (chl-*a*) and biofilm ash free dry mass (AFDM) on the tiles were measured. Values for all three parameters were highest on grazer excluded tiles from open sites. Grazed tiles from open sites accrued less *Cladophora* yet they still carried moderately high levels of chl-*a* and AFDM. Tiles from shaded sites accrued no *Cladophora* and carried the lowest chl-*a* and AFDM levels. Remarkably, we measured a small increase in chl-*a* and AFDM on tiles from shaded-sites subjected to grazer exclusion compared to the shaded site control tiles. Tiles fully covered with *Cladophora* were found in open, grazer-excluded sites upstream, down stream and near a nutrient point source. However, we found that between tiles *Cladophora* variation was greatest at the upstream stretch, medium at the downstream stretch and lowest near the nutrient input, indicating that *Cladophora* growth potential was similar for all stretches, but that realized growth was lower in the nutrient-poor stretches. The average number of grazers colonising the control tiles was positively correlated to the nutrient levels. However, grazer body size was inversely correlated. The developed electrified-tile method provides an insight into the dynamic balance between top-down control (grazers) and bottom-up control (light and nutrient limitation) and has potential to be used as a method to monitor the risk of *Cladophora* blooms.

TOWARDS ECOSYSTEM-LEVEL POLLUTION ECOLOGY: INTEGRATIVE RESPONSES OF INVERTEBRATE CONSUMERS TO NUTRIENT ENRICHMENT

Gabriel A. Singer and Tom J. Battin

Department of Freshwater Ecology, University of Vienna, A-1090 Vienna; Wassercluster Biologische Station Lunz GmbH, A-3293 Lunz am See.

Abstract:
Traditionally invertebrates in lotic ecosystems have been used as bioindicators for organic pollution following at best a species-specific ecophysiological approach. Additionally, routine analyses of community composition based on functional feeding guilds or biocoenotic regions using published catalogues of species traits have introduced a more system-oriented and functionally interpretable assessment of stream health. Ecological stoichiometry predicts a certain degree of homeostasis for heterotrophic consumers. Though elemental composition may be highly variable as a function of species traits such as life history and taxonomical context, it can be regarded as relatively constant for an individual consumer species, which is not necessarily true for its allochthonous or autochthonous resource base. We argue that elemental composition should be regarded as a species trait putting constraints on an individual´s survivorship dependent on existing resources in a given environment. Biomass stoichiometry could thus potentially determine a species´ existence/abundance in a given ecosystem and increase its bioindicatory value with the possibility for system-level functional interpretation. Using a case study of a headwater stream impacted by a sewage treatment outfall, we show integrative responses of the macroinvertebrate community to enrichment with carbon, nitrogen and phosphorus. Rather than focus on changes of community composition at species-level, we use elemental composition in conjunction with stable isotopes to describe more mechanistically interpretable changes in community structure and function. We demonstrate functional alterations to the food web and differential reaction of taxa and functional feeding groups to an anthropogenically derived resource subsidy with defined qualities leading to community-level changes of nutrient fluxes. The reported reactions contribute to an integrative diagnosis of ecosystem health, i.e. an assessment of functional integrity, which could facilitate future management of the anthropogenic subsidy and the recipient stream in our case study. Our study delivers an example for how assessment and management of a broad range of impaired stream ecosystems could be advanced using modern ecological theory and techniques.

EFFECT OF WATER NUTRIENT CONCENTRATION AND N:P MOLAR RATIO ON BIOFILM STRUCTURE AND METABOLISM

Sergi Sabater[1,2], Joan Artigas[1] and Anna M. Romaní[1]

[1]Institut d'Ecologia Aquàtica, Departament de Ciències Ambientals, Universitat de Girona, Campus de Montilivi, E-17071 Girona, Spain
[2]Catalan Institute for Water Research (ICRA), Parc Científic i Tecnològic de la Universitat de Girona, E-17003, Girona, Spain

Abstract:
Epilithic biofilms may differ in terms of their composition and metabolism with regard to the intensity and type of nutrient enrichment. Potential effects of water nutrient concentration (N and P) and N:P molar ratio may include their ability for nutrient uptake, as well as their stoichiometry and trophic connections. This was the question analyzed in a mesocosm experiment. Mature biofilms grown on unglazed glass tiles (1 cm^2) were colonized in the field (two months), and then exposed to four water treatments N:P= 16:1 and N:P= 56:1, each at high (HN) and low (LN) nutrient concentrations during 35 days. During seven sampling times, biofilm response was analyzed by means of algal and bacterial biomass, biofilm CNP content and polysaccharide content in EPS. Three extracellular enzyme activities (cellobiohydrolase, leucine-aminopeptidase, phosphatase) which are involved in organic matter decomposition were also analysed. Water nutrient concentration (N and P) had positive effects on algal and bacterial biomass accrual in biofilms, as well as on the stimulation of peptidase activity. The increase of peptidase activity suggested a higher N recycling which is consistent with the increase of available nitrogenous compounds mostly released from algal growth. Instead, the increase of water N:P ratio (56:1 treatments) reduced bacterial biomass, but did not affect algae, and stimulated phosphatase activity. The high sensitivity of bacterial biomass to the water N:P imbalance (low P availability) was probably related to their major dependence on water nutrient availability and lack of nutrient storage capacity. Though algal biomass did not respond to water N:P increase, an important accumulation of polysaccharide content in EPS was observed. The response of enzyme activities (day 7) and microbial biomass (day 3 for bacteria and day 21 for algae) was faster than that observed for biofilm CNP content, because biofilm nutrient molar ratios remained unaltered until days 28 to 35. Water nutrient concentration diminished the biofilm C:N, but not C:P. Conversely, the increase of water N:P increased biofilm C:P and N:P. Biofilm N:P agreed to that of 16:1 (19.8) and 56:1 (44.7) water treatments at the end of the experiment, suggesting that nutrient composition of biofilms was tightly related to changes in water N:P. Contrary to our predictions, the interaction between the two factors (nutrient concentration and N:P ratio) was not statistically significant for any of the biofilm analyzed parameters. This suggested that each factor had independent effects in modulating biofilm structural and metabolic parameters.

MONITORING NUTRIENT ENRICHMENT IN RIVERS WITH MACROINVERTEBRATES

John Lucey

Environmental Protection Agency, Seville Lodge, Callan Road, Kilkenny, Ireland

Abstract:
A single scheme of river/stream classification, employing macroinvertebrates, has been in use in Ireland to monitor the effects of eutrophication/organic pollution for almost 40 years. Lately this scheme, known as the Quality Rating System (Q-value), has been applied as the metric for ascribing Ecological Quality Ratios (EQRs) for the benthic invertebrate fauna element in the river-monitoring programme under the Water Framework Directive (WFD). For Operational Monitoring the macroinvertebrate metric is the primary indicator used while at Surveillance Monitoring sites the full suite of ecological elements (i.e. fish, benthic invertebrates, macrophytes and phytobenthos) is employed. Nutrient enrichment, by phosphates and nitrates, has direct as well as indirect effects on taxa. *Margaritifera margaritifera* is regarded as among the most nutrient sensitive of the aquatic invertebrates and the objective of High Status (EQR $\geq$0.90) has been set in areas designated for its conservation. Comparison of nutrient levels with ecological Q-values shows a strong negative correlation. Unimpacted sites with high ecological quality correspond with mean Molybdate Reactive Phosphate (MRP) and Oxidised Nitrogen concentrations of 0.022 mg/l P and 0.76 mg/l N, respectively.

MONITORING NUTRIENT ENRICHMENT WITH DIATOMS

Martyn Kelly

Bowburn consultancy, UK

Abstract:
Diatoms have been used widely for monitoring nutrients since the early 1990s and many national assessment systems for the Water Framework Directive (WFD) use diatoms. However, many Member States have chosen to use existing indices without a critical assessment of their suitability to meet the challenges posed by the WFD. In particular, the role of diatoms as proxies for phytobenthos has not been explored in detail and there is no clear consensus on how ecological status concepts apply to diatoms. This talk will explore how diatoms can be used as part of a toolkit of methods to provide an understanding of the "macrophytes and phytobenthos" quality element that will provide a firm basis for decision making.

MANAGING STREAM EUTROPHICATION – NOW YOU SEE IT, NOW YOU DON'T

Chris Mainstone

Natural England, UK

Abstract:

The science of riverine eutrophication is not well developed compared to its lacustrine counterpart. The lack of a coherent and well presented science base for riverine eutrophication creates difficulties for those responsible for protecting river ecosystems across the world. The complexities of environmental (abiotic and biotic) processes governing the manifestation of eutrophication-related symptoms in rivers, the strength of some of these factors in limiting such manifestations in some situations, and the scale of potential management costs of restoring nutrient levels to ecologically relevant levels, make river eutrophication one of the larger management headaches in the freshwater environment. As management regimes for river eutrophication move away from traditional models associated with incremental removal of the worst excesses of nutrient pollution, towards models involving strategic action to meet ecologically relevant nutrient thresholds, so the need for a robust science base and an associated scientific consensus increases. The scale of investment in phosphorus removal from sewage and other effluents to control river eutrophication is already considerable, but it is generally only those pollution sources that are easiest to control that have so far been addressed with any conviction. The costs of action to date may be dwarfed by the potential costs of remaining action on more difficult sources to bring nutrient levels down to ecologically appropriate levels. This paper attempts to describe how environmental managers currently confront the river eutrophication dilemma, drawing on experiences in the UK of working with European and domestic environmental and wildlife legislation. It outlines a vision for future management of river eutrophication which is based on a clear rationale for dealing with scientific uncertainty across different policy drivers, a plan for reducing this uncertainty over time through concerted, strategic science, and an integrated framework for developing acceptable nutrient regimes in catchments for the protection of all freshwater habitats.

List of participants:

Archbold Marie	QUB EPA
Aubry Aurelie	University College Cork, Ireland
Bradley Catherine	EPA, Ireland
Chapman Debbie	University College Cork, Ireland
Creed Karen	EPA, Ireland
Dalton Linda	EPA, Ireland
Dang Christian	University College Cork, Ireland
Drinan Thomas	University College Cork, Ireland
Edwards Tony	ex-MacAulay Institute, UK
Emmerson Mark	University College Cork, Ireland
Flinn Ray	EPA, Ireland
Gessner Mark	Eawag / ETH Zurich, Switzerland
Giller Paul	University College Cork, Ireland
Graham Conor	University College Cork, Ireland
Harper Bruce	EPA, Ireland
Harrison Simon	University College Cork, Ireland
Humphreys James	Teagasc
Hutton Steve	University College Cork, Ireland
Jansen Marcel	University College Cork, Ireland
Kavanah Jane	University College Cork, Ireland
Kelly Martyn G.	Bowburn consultancy, UK
Kelly Quinn Mary	University College Dublin
Low Jonathan	University College Cork, Ireland
Lucey John	EPA, Ireland
Madden Donncha	Teagasc
Mainstone Chris	Natural England, UK
McCarthy Alison	EPA, Ireland
McCreesh Patricia	EPA, Ireland
McGarrigle Martin	EPA, Ireland
Murtagh Padraig	Longford County Council
O'Breasail Sean	Cork County Council
O’Callaghan Richard	University College Cork, Ireland
O'Driscoll John	University College Cork, Ireland
O hUallachain Daire	Teagasc
Reynolds Jacinta	Cork County Council
Sabater Sergi	University of Girona, Spain
Sheehy Sorcha	DixonBrosnan Environmental Consultants
Singer Gabriel	University of Vienna, Austria
Sturt Michael	University College Cork, Ireland
Toner Paul	EPA, Ireland
Wemaere Alice	EPA, Ireland
Willby Nigel	University of Stirling, UK