

**The macrophytic vegetation
of the major rivers of Luxembourg**

by

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I. INTRODUCTION

Purpose of survey

This survey was commissioned by the Ministry of Environment of Luxembourg following complaints by anglers of a decrease in vegetation (a loss of *Ranunculus* being particularly mentioned). The possibility of damage from herbicides was raised particularly that from atrazine, since this is used in maize fields and maize-growing has much increased in recent years.

The aims of the survey were twofold: Firstly, to establish a base-line inventory of the actual aquatic vegetation of macrophytes in the main rivers of Luxembourg, in order to be able to follow future changes.

The second aim was to assess the amount of vegetation damage in the main rivers of Luxembourg and whether this pollution could be ascribed to a particular type or source. The comparison with earlier investigations in 1977-80 shows some changes and trends in this pollution damage during the recent past.

Generalities

On looking at a river, one of its most obvious features is its "weed" (macrophytic vegetation). This may be pleasing or displeasing to the eye and be useful as creating habitats for invertebrates and fish and hence for anglers, or be useless for man's purposes, as when it creates a flood hazard or prevents easy angling. All organisms, including these larger plants, grow in conditions favourable to themselves and avoid habitats too unfavourable. Therefore, once the habitat preferences of species are known, the living communities present in any river can be used to interpret the conditions of that river as they affect them.

The quality of rivers can be assessed in many ways. These include chemical analysis of water (or soil), invertebrate surveys and indices, macrophyte (large plant) surveys and indices, diatom surveys and indices, fish surveys, chemical analysis of molluscs and analysis of mosses, among others. If a river is completely clean, this will be shown on all indices. If a river is grossly polluted by a range of chemicals, likewise all methods will indicate this gross pollution.

However, when pollution is mild or consists of only a small range of chemicals, different methods will lead to rather different results. This does not mean any of the methods are wrong. It means that the different methods are assessing rather different aspects of pollution.

There are several thousand different chemicals in rivers. Naturally only a few can be analysed and these are chosen as indicating some particular aspect of pollution and as being easy to measure - e.g. oxygen status is measured by B.O.D. and dissolved oxygen, the organic state is partly indicated by B.O.D. and ammonia, inorganic nutrients by nitrate and phosphate and heavy metals by, say, cadmium and mercury. The number chosen for analysis varies with circumstances. The disadvantage is that the measurement is accurate for these few chemicals on the day of sampling only.

Biological sampling assesses the total chemical environment, all chemicals integrated over the whole time, since the organism is living within this environment (Molitor, 1974). The disadvantage is that it is difficult to tell which chemicals and at what concentrations are causing the damaging pollution (Molitor & Van Hooren, 1984). In addition, different types of organisms are especially sensitive to different groups of chemicals: in the same way that herbicides sprayed on crops are, though dangerous to man, less lethal than they are to crop weeds. Invertebrates are particularly sensitive to oxygen deficiency and heavy metals. Mollusc and moss analysis are particularly suitable for assessing heavy metals. Macrophytes are especially sensitive to the toxicity of organic pollutions and, of course, herbicides. In addition, macrophytes, unlike the other groups, are mainly rooted in the soil, so assess soil as well as water pollution.

When different biological methods produce different results it means different types of pollution are being measured. For instance, below the entry of a mild organic waste, macrophytes will decrease because of the toxicity. Invertebrates are more likely to decrease further downstream where the oxygen supply is least. And, if the oxygen is only affected slightly, these may hardly decrease at all. Similarly if there is a waste consisting of unaltered plant material (celluloses and starches) the macrophytes will be affected only slightly, but the oxygen demand of the waste will be great and the invertebrate index will drop sharply some way below the effluent. An organic pollution with a very high B.O.D. but a low toxicity can lead to good vegetation and atrocious fauna. Examples could be multiplied, but it is important to realise that discrepancies between indices are significant because they add extra information on river quality. They do not mean the methods used or the scientists concerned are inefficient or wrong.

Types of pollution

In Luxembourg, as in other countries, pollution may come from various sources, the principal possibilities being:

1) **Organic pollution.** In overall terms this is the most important. It consists of treated and untreated domestic sewage, farm wastes, effluents from factories concerned with organic materials (e.g. sewage plants, abattoirs, dairy products or productions of plastics). The vegetation patterns vary with the type of treatment as well as with the nature of the original effluent.

2) **Industrial effluents** other than organic products from factories and other works of various types. The substances vary from cyanide to heavy metals. They may be discharged directly into the river or may enter via sewage treatment works. In addition, increasing amounts of household chemicals are being added to domestic sewage, blurring the distinction between industrial and domestic wastes.

3) **Wash from roads** chemically falls into (1) and (2), but instead of entering the river at fixed points where at least in theory it can be cleaned, it enters over a more diffuse area. Apart from the basic dirt always occurring,

any accident adds chemicals, whether merely petrol or fire-fighting materials, or tanker spillages; and, in winter, salt and other anti-freezing agents used for instance at the airport.

4) **Inorganic nutrients** such as phosphate, ammonia and nitrate: substances needed for the good growth of macrophytes but which, in excess, may kill or alter plant life. These enter together with (1), (2) and (3). In fact it is possible that where sewage pollution contains high quantities of anions the vegetation may be greatly reduced, but where it contains less anions but high levels of organics or chloride, *Potamogeton pectinatus* may become abundant (Haslam, 1987). In the Saprobic and some other systems of pollution classifications, inorganic nutrients and organic wastes are considered together. Since the response of macrophytes to the two is very different, it is advisable to separate them. Tests indicate toxic effects from nutrients may occur immediately downstream of sewage works, but the effects on vegetation from organics etc. persist much longer. The proportions vary with different treatments.

Inorganic nutrients have a second source: the land. When grassland is first ploughed, nutrients may be released in large quantities and washed into the rivers. Some formerly permanent grassland in Luxembourg has been recently ploughed. Secondly, fertiliser added to the land reaches the watercourses. This may happen by direct run-off and leaching. This will be greatest if a storm follows shortly after fertiliser application. Alternatively, in the aquiferous rocks, the fertiliser percolates down and contaminates the ground-water so that when this rises to the surface and reaches the streams it is already polluted. Ditch vegetation alters when land is converted from wet grassland to arable, even when the water depth remains the same.

5) **Biocides**, both pesticides (killing animal pests) and land herbicides (killing plants and plant diseases). Like fertilisers, biocides are a diffuse source of pollution. They can enter the streams by run-off and leaching in any area where they have been applied in the catchment. I have as yet seen no evidence that they appear in ground-water from aquifers, but such a possibility cannot be ignored. Biocides typically degrade, but in some cases the degradation products are at least as toxic to macrophytes as the original substances.

Substances entering a stream are entering a near-closed environment. They may be moved downstream in the water, perhaps being chemically altered (downstream purification) or they may be deposited on the bed, accumulating most in the silt. Here also they may be chemically altered and may be washed downstream in the silt. They can leave the system only by, for example, dredging or leakage from the bed. Toxic substances from many places (towns, farms, factories and fields) may thus accumulate and become concentrated in the streams, polluting these and polluting the major rivers into which they flow. Both river chemical (e.g. oxygenation) and biological (bacterial etc) agents may contribute to render this pollution harmless, but some substances are resistant to such processes even in small concentrations. Others are resistant to downstream purification if the concentrations are high, or are constantly being added to by further effluents (as can happen with sewage works effluents from closely-spaced villages).

Effects of pollution on river vegetation

Pollution affects river vegetation by:

1) decreasing the occurrence and frequency of the species sensitive to the relevant pollutant. This leads to a reduction in the number of species present at each site. In general terms, the first species to be lost are those most sensitive to (most easily harmed by) the pollutant in question. As the pollution increases, the semi-tolerant species are lost, leaving those most tolerant. Next there remain only species which happen to be favoured (increased) by the pollution and finally, when the pollution becomes excessive, vegetation is absent.

2) decreasing the cover, the amount of channel covered by the plants (other than that of any species actually increased by the pollutant).

3) increasing the occurrence, frequency and cover of any species that are favoured by moderate levels of the relevant pollutant.

If the total nutrient regime is increased enough to affect macrophytes (e.g. increases from an oligotrophic to a mesotrophic habitat), the species assemblage shifts in a corresponding fashion. This can be assessed since the nutrient patterns of different species are known (see Haslam, 1987). (Temporary wash-outs of fertilisers do not come into this category. They may have no effect or, it is reported, may cause increased growth of the existing species.)

If organic wastes are sufficient to harm the vegetation the alteration to the plant community is again characteristic. The pattern is easily determined since there are so many sewage treatment works etc, whose effect can be measured. The species sensitive and tolerant to such pollution are known and used in the Haslam index.

It is more difficult to assess the effects of herbicides. It appears that in general the tolerant species are tough, probably large, emergent aquatics and the sensitive ones are frail water-supported species. Unfortunately few tests have been done on the effects of land herbicides in rivers and different herbicides will have different effects. The above comment is based on the writers's observations on American rivers known to be poisoned by land herbicides. (The effects of aquatic herbicides have been studied in some detail, but are irrelevant in this context). Herbicides are discussed further in Part IV.

An index can be created for macrophytes for any pollutant, provided the species sensitive and tolerant to that pollutant can be determined. The vegetation pattern for each pollutant follows the three criteria named above.

II. METHOD OF SURVEY

The survey was carried out in August 1985 with the active help of the Service de la Chasse et de la Pêche of the Administration des Eaux et Forêts of Luxembourg.

Table 1. Stream damage rating

In criteria 2, 3 and 4 the site vegetation is compared with the minimum expected in a similar undamaged site assessed as given in Table 2. For criterion 5, a list of species tolerant and semi-tolerant to this pollution is compiled in Table 3.

1. Species diversity allowance *

No. species present:	0	1-2	3-4	5-6	7-8	9+
Assign figure of:	5	4	3	2	1	0

2. Decrease in diversity: difference between expected and actual number of species *

3. Percentage decrease in percentage cover

Percentage loss in cover
in water up to

1 m deep	100	80-95	60-75	40-55	20-35	0-15
Assign figure of:	5	4	3	2	1	0

4. Change in trophic status band (Table 4)

Change:	More than one band	One band or change to uncertain or nil	Half band	Dubious change	No change
Assign fig. of:	4	3	2	1	0

5. Percentage of pollution-tolerant species

See Table 4.2. Add 1 for each tolerant species (and for land species rooted in streams iii-v), $\frac{1}{2}$ for each semi-tolerant one

Nil species	100%	75-95	50-70	30-45	15-25	0-10
tolerant	%	%	%	%		
Assign figure of:	5	4	3	2	1	0

Add 4 if only sensitive species are present but the number present is not over one-sixth of those expected and 3 if one quarter (or approx.)

6. Weighting for *Potamogeton pectinatus* and blanket weed

(Pot. = *Potamogeton*)

	Much Pot. <i>pectinatus</i>	Sparse Pot. <i>pectinatus</i> the only species present	Much blanket weed
Assign fig. of:	4 (2 if intermediate)	1	2

* Mosses restricted to man-made structures (bridge piers, concrete slopes etc.) should be disregarded.

In some instances aggregates are used instead of species, eg *Callitriche* ssp (excluding *C. hamulata*) and all mosses.

(Table 1 continued)

Total	Damage rating
0-4	a
5-7	b
8-10	c
11-13	d
14-16	e
17-18	f
19-21	g
22+	h

If channels with over 15% cover are assessed as h, they are automatically reclassified as g

The vegetation occurring at point sites (usually bridges) was recorded intermittently along the rivers, using the method described in Haslam and Wolseley (1981) and Haslam (1982) for Britain, with local modifications as described in Haslam (1987) and Wolff (1987). Nearly 200 sites were recorded in four and a half days. This type of survey thus enables a general picture to be given of large areas in a short time. However, the interpretation is only for the sites (and years) of survey: pollutions or disturbances occurring between sites and from which the vegetation has recovered between these sites, are not included. In addition, the shortness of the survey did not allow either a long examination of each site or repeat visits to any sites.

Once the ecological principles determining river vegetation are understood, indices for assessing any of these controlling factors can be devised. A general damage (including pollution-damage) rating is given below. It is applicable where vegetation is both plentiful and predictable, e.g. to streams in lowlands and low hills which are large enough to bear water-supported species.

III. RESULTS

For each river the sites are arranged in order from upstream to downstream, with tributaries placed where they enter the main river.

The sites were mostly bridges (where the whole width of larger streams can be examined). A few sites, however, were examined from one side only.

The survey was for prominent species: this is sufficient to interpret vegetation patterns (though inadequate for surveys intended to locate rare species, or fully assess areas for conservation). The species which were included (when prominent) were angiosperms, *Equisetum* spp, mosses (as an aggregate), *Enteromorpha* sp., and 'Blanket weed'. This last is a local English term, denoting trailing filamentous algae, usually *Cladophora* sp. Such filamentous algae are present in most sites, but with easily-visible

Table 2: Plant community data for damage rating

The top line gives the stream size. i up to 3 m wide, no water-sup-ported species, no damage rating. ii up to 3 m wide, water-supported species present. iii 4-8 m wide. iv 10+ m wide.

The second line gives the minimum expected diversities, covers and the expected nutrient status bands at point sites (e.g. bridges) in undamaged communities.

A brief description of typical streams is listed next, followed by the more characteristic species.

1. Lowland region

Lowland (flat to hilly). Gorges present and unless flow is regulated by frequent controls (as in river Alzette), vegetation is much impoverished in these by high water force. Much pollution (Blanket weed and, in large streams, *Potamogeton pectinatus*, common).

i

1 - 4 + spp 15 + % cover (mesotrophic etc)

Infrequent, 1-3 m wide, 20-30 cm deep, slow flow, mixed substrate, clear water. Probable species:

<i>Ber. erecta</i>	<i>Ir. pseudacorus</i>	Small grasses
<i>Glyceria maxima</i>	<i>Ph. arundinacea</i>	

ii

5 + spp 60 + % cover mesotrophic (to slightly eutrophic)

Frequent. 0.5-3+ m wide, 20-30 cm deep, moderate flow, mixed-gravelly substrate, clear water. Blanket weed solely due to damage.

Often abundant:

<i>Callitriche spp</i>	<i>Elo. canadensis</i>	<i>Ph. arundinacea</i> (as fringe)
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Often associated:

<i>Agr. stolonifera</i>	<i>My. scorpioides</i>	<i>Zan. palustris</i>
<i>(Gly. maxima)</i>	<i>Ranunculus spp</i>	(Moss)
<i>(Groen. densa)</i>	(medium and	Blanket weed?
<i>Ir. pseudacorus</i>	short-leaved)	

iii

7 + spp 70 + % cover slightly eutrophic

Frequent. 4-8 m wide, 30-75 + cm deep, slow (-swift) flow, substrate varied (including bouldery), clear water.

Often abundant:

Ph. arundinacea (as fringe)

Often associated:

<i>Agr. stolonifera</i>	<i>My. scorpioides</i>	<i>Ranunculus spp</i> (medium
<i>Elodea canadensis</i>	<i>Nuphar lutea</i>	and short-leaved)
<i>Ir. pseudacorus</i>	<i>Pot. crispus</i>	<i>Zan. palustris</i>
		Moss

iv

8 + spp 80 % cover slightly to semi-eutrophic

Infrequent, 8-15+ m wide, 40 cm - 1+ m deep, slow-fast flow, substrate variable but at least partly silty or sandy, clear water.

Often abundant:

Ph. arundinacea (as fringe)

Often associated:

<i>Agr. stolonifera</i>	<i>Myr. spicatum</i>	<i>Ranunculus spp</i>
<i>But. umbellatus</i>	<i>Pot. crispus</i>	(medium-long leaved)
<i>Elodea canadensis</i>	<i>Pot. nodosus</i>	<i>Sparganium emersum</i>
<i>Ir. pseudacorus</i>	<i>Pot. perfoliatus</i>	Mosses

(Table 2 continued)

2. Highland region

Upland and mountainous mainly. The latter is more damaged by high water force and is more impoverished than the undamaged communities listed below (damage ratings doubtful).

i
1-4 + spp 15? % cover mesotrophic

Frequent. 1-3 m wide; 10-20 m deep, moderate flow (-fast + less vegetation), gravelly-mixed substrate, clear water.

Probable species:

<i>Mentha aquatica</i>	<i>Ph. arundinacea</i>	<i>Veronica beccabunga</i>
<i>My. scorpioides</i>	<i>Sol. dulcamara</i>	Small grasses

ii
5 + spp (2+, mountains) 60+% (5?) cover (slightly oligotrophic to) mesotrophic

Infrequent. 1-3 m wide, 30-50 cm deep, moderate flow (-fast + less vegetation), stony-mixed substrate, clear (or brown-stained) water.

Often abundant:

<i>Ph. arundinacea</i>	<i>Ranunculus</i> (shortish leaves)
(as fringe)	

Often associated:

<i>Mentha aquatica</i>	<i>Ror. nasturtium-</i>	Small grasses
<i>Pet. hybridus</i>	<i>aquaticum</i>	Mosses
(shade)	<i>Ver. beccabunga</i>	

Variant: slightly oligotrophic, also with e.g.

<i>Call. hamulata</i>	<i>Glyceria fluitans</i>
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iii
7 + spp (1+ mountains) 50+% (5?) cover mesotrophic

Frequent. 4-8 m wide, 20-75 cm deep, alternating slow/faster flow, mixed to coarse substrate, clear or brown-stained water.

Often abundant:

<i>Ph. arundinacea</i>	<i>Ranunculus</i> sp. (medium leaves)
(as fringe)	

Often associated:

<i>Ag. stolonifera</i>	<i>Ir. pseudacorus</i>	Moss
<i>Carex</i> sp	<i>Mentha aquatica</i>	

iv
7 + spp (1+, mountains) 40+% cover mesotrophic (to slightly eutrophic)

Infrequent. 10-15 (-60+) m wide, 40 cm - 1+ m deep, slow, moderate (+ or -) flow, mixed (and silt, coarse) substrate, clear water.

Often abundant:

<i>Ph. arundinacea</i>	<i>Ranunculus</i> sp. (medium long leaves)
(as fringe)	

Often associated:

<i>But. umbellatus</i>	<i>Mentha aquatica</i>	<i>Sparganium erectum</i>
<i>Carex</i> sp.	agg.	Small grasses
<i>Ir. pseudacorus</i>	<i>Pol. hydropiper</i>	Moss

Ag.=*Agrostis*; *Ber.*=*Berula*; *But.*=*Butomus*; *Gly.*=*Glyceria*; *Groen.*=*Groenlandia*;
Ir.=*Iris*; *My.*=*Myosotis*; *Myr.*=*Myriophyllum*; *Pet.*=*Petiasites*; *Ph.*=*Phalaris*;
Pol.=*Polygonum*; *Pot.*=*Potamogeton*; *Ror.*=*Rorippa*; *Sol.*=*Solanum*; *Ver.*=*Veronica*;
Zan.=*Zanichiella*.

Table 3: Pollution-tolerant species

1. Tolerant

<i>Agrostis stolonifera</i>	<i>Potamogeton nodosus</i>
<i>Glyceria maxima</i>	<i>Potamogeton pectinatus</i> *
<i>Phlaris arundinacea</i>	Blanket weed *
<i>Potamogeton crispus</i>	

* also favoured by pollution

2. Semi-tolerant

<i>Glyceria</i> , small spp *	<i>Scirpus lacustris</i>
(+ <i>Catabrosa aquatica</i>)	
<i>Iris pseudacorus</i>	<i>Sparganium emersum</i>
<i>Lemna minor</i> agg.	<i>Sparganium erectum</i>
<i>Phragmites communis</i>	<i>Typha</i> spp
<i>Rorippa amphibia</i>	

* excluding long-leaved *Glyceria fluitans*

trailing filaments in only some. It is the latter which from part of the macrophyte community. Benthic algae are recorded only when Blanket weed is absent, or when some special feature occurs (e.g. transitional to sewage fungus). Benthic algae are not used in this macrophyte index.

Some taxonomic difficulties were encountered. *Callitriche* spp is used to include *C. platycarpa*, *C. stagnalis*, *C. obtusangula* and *C. cophocarpa*, since these can grow entangled and the less prominent be impossible to identify without laboratory tests. Mademoiselle Claudine Wolff (1987) however, has identified *C. platycarpa* as alone occurring on the upper (Luxembourg) part of the Sure and so this species may be the main or sole one elsewhere. *Carex* spp were recorded as two aggregates. *C. acuta* agg. of which at least some records were *C. acuta*, and *C. acutiformis* agg., of which *C. riparia* is likely to be frequent in this part of Europe. The two Batrachian *Ranunculus* spp occurring are, according to the local floras (the general taxonomy of this group is in disarray), *R. penicillatus* for the short-medium leaved form found in more upstream areas and *R. fluitans* in large and downstream reaches. Both are referred to here as *Ranunculus* sp. The small *Glyceria* spp (*G. fluitans*, *G. plicata*, *G. declinata*) STA1 are aggregated, except where *G. fluitans* has long floating leaves, where it is listed separately. This form is normally characteristic of oligotrophic habitats.

Unfortunately *Sparganium erectum*, a widespread species and *Acorus calamus* a local one (which may be locally very frequent) can easily be confused at a distance unless *A. calamus* is known to occur in the locality.

Table 4: Nutrient-status banding of species

Oligotrophic habitat

Menyanthes trifoliata
Myriophyllum alterniflorum
Callitriche hamulata

Juncus bulbosus
Hydrocharis morsus-ranae

Mesotrophic

Mosses (hard rocks)
Petasites hybridus
(Carex acuta/acutiformis)
Ranunculus aquatilis/peltatus
Veronica beccabunga
Berula erecta
*Callitriche spp **
Chara sp.
Mentha aquatica
 (Blanket weed in hills and sparse)
Glyceria, small spp, short-leaved
Catabrosa aquatica
 Mosses (soft rock)

Rorippa nasturtium-aquaticum
Ranunculus penicillatus agg.
Solanum dulcamara
Lemna trisulca
Myosotis scorpioides
Ranunculus fluitans
Equisetum palustre
Apium nodiflorum
Veronica anagallis-aquatica agg.
Sparganium erectum
Potamogeton natans
Polygonum amphibium

Slightly eutrophic

Nymphaea alba
Elodea canadensis
Iris pseudacorus
Carex acutiformis agg.
Ceratophyllum demersum

Typha latifolia
Phragmites communis
Potamogeton perfoliatus
Groenlandia densa
Zannichellia palustris

Semi-eutrophic

Blanket weed
Ranunculus sceleratus
Potamogeton crispus
Glyceria maxima
Alisma plantago-aquatica
Myriophyllum spicatum
Rumex hydrolapathum/longifolius
Enteromorpha sp

Rorippa amphibia
Sparganium emersum
Sagittaria sagittifolia
Butomus umbellatus
Potamogeton pectinatus
Scirpus lacustris
Nuphar lutea

Obvious *A. calamus* was noticed only on the last day of the survey, in the lower Sure. It is possible that records given as *S. erectum*, recorded earlier in the survey, include ones of *A. calamus*. Lastly, owing to inattention, inadequate care was taken in the separation of *Apium nodiflorum* and *Berula erecta* and these records may be confused. However deplorable these last two are on grounds of accuracy, for the purpose of pollution assessment, fortunately, it is immaterial in this part of Europe.

The records are arranged under:

Site, located by name of relevant village or town. Further information can be found from the relevant River Map.

Emergent Species (Em) (Plants whose normal growth habit is mainly above water). Only those within, or very close to, the water on the date of record were included, the latter being entered in brackets. These are listed in alphabetical order. Species living in "marsch" conditions at the edge are excluded (since pollution affects them much less). Consequently emergent aquatics able to grow in both habitats (e.g. *Phalaris arundinacea*) are in the lists only if occurring within the water. "F" after the name indicates that for at least part of the edge, the species forms a fringe to the watercourse. "A" after the name indicates the species is abundant: for emergents this may mean a high cover over the bed of a small stream, or abundance in the available habitat (the edge), but a low cover in respect of the whole watercourse.

Water-supported species (WS). This term is used to describe both floating and submerged species. Various species, e.g. *Berula erecta*, *Butomus umbellatus*, *Sparganium emersum* can occur in both emergent and water-supported forms. They are placed under their usual habit, and if they were present in the other and the difference is of ecological significance, then the habit is noted. The species are arranged in alphabetical order of higher plants, followed (if relevant) by mosses and algae. "A" after the name indicates the species is abundant. This may mean a higher cover over the bed of a shallow stream or much present in water less than 1m deep at the sides of a large river, but a low cover in respect of the whole watercourse.

Cover. Where the plant cover in water up to 1m deep is over 10%, this is noted. Benthic algae are not included (though Blanket weed is).

Damage rating. This is given on the *a* (good) to *h* (bad) scale.

River Maps

The river outlines have been copied from maps supplied by the Administration des Eaux et Forêts. Irrespective of the actual compass direction of flow, each has been placed to flow from the top to the bottom of the page for easy comparison. Scales and various towns and villages have been marked.

The surveyed sites are marked on the river where these are known. Main river sites whose exact locations are unknown are placed to the side. Minor tributaries are marked with an asterisk.

The species at each site have been listed as described above.

The choice of species to record as river species has followed the conventions adopted by Haslam, Kohler et al. (1982), who confined the recorded species to those rooted well into the water.

Site lists for 1985 are given without brackets, though round brackets are used for species doubtfully aquatic (see above). Records for earlier years are given in square brackets, each preceded by the year of survey. Less attention was paid to the location of sites in the earlier years as no re-survey was expected, so a number of these earlier records do not have exact sites marked on the rivers.

The contractions used for each species on the River Maps can be elucidated by comparing the lists on the Maps with the full lists. Names underlined on the Maps are those marked "A" in the table: the species occurring abundantly at the site.

THE RIVERS

1. The river ALZETTE

The Alzette rises in the industrial lowland south of the country. It then flows through the large city of Luxembourg (around which it lies in a gorge which, because of the nature of the land and the management of the river, does not cause swift flow), and on through villages and towns, receiving various side rivers, principally the Mamer, Eisch and Attert (all of which are polluted), finally flowing into the Sure past the town of Ettelbruck. With so much industry and settlement it is not surprising that the river is seriously polluted throughout its length. The banks are often unstable and slump. In contrast to the Attert, however, the vegetation is not diminished by an unstable bed.

The Alzette stands out as the river with abundant *Potamogeton pectinatus*. This is a species favoured and often brought in by pollution, particularly by organic pollution, certain types of industrial effluents and salt. Filamentous algae ("Blanket weed") is often abundant. In such rivers Blanket weed also occurs with pollution from high levels of anionic nutrients.

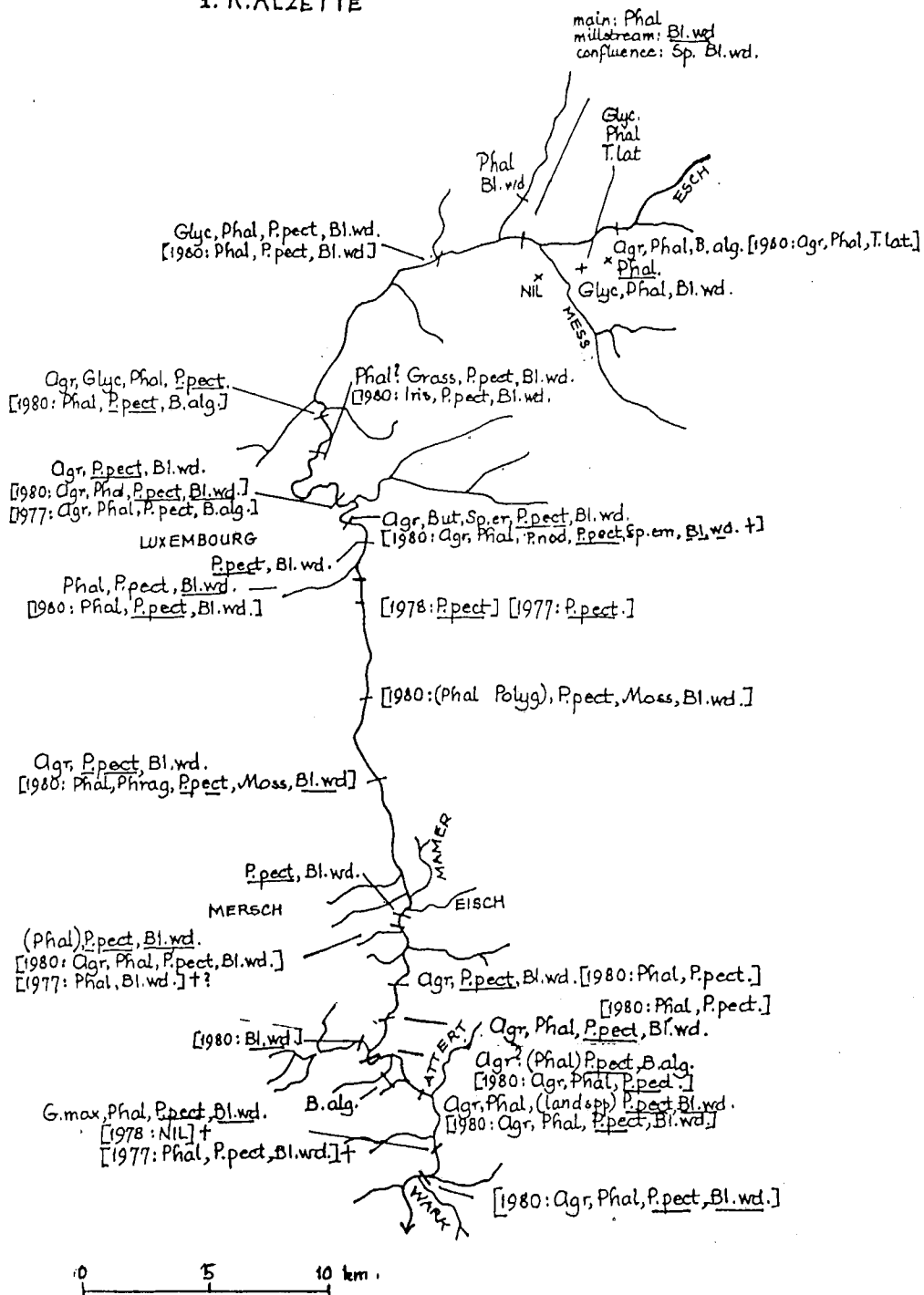
Taking the simplest measure, that of the number of species present other than *P. pectinatus* and Blanket weed, the condition of the Alzette has not improved since 1980, nor where the records exist, since 1977/78. The slight variations which occur are no more than those occurring naturally in river habitats. These are ever-changing yet basically stable in stable conditions.

1. RIVER ALZETTE

SITE		SPECIES	COVER	DAMAGE RATING
Schiffflange	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	-	g
	WS	Benthic algae		
Near Schiffflange (ditch)	Em	<i>Ph. arundinacea</i> A	100%	-
Near Bergem (trib. Mess)	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> , <i>Typha latifolia</i>	10%	e
Bergem, Mess	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i>	10%	e
	WS	Blanket weed		
Near Bergem	Em	<i>Ph. arundinacea</i>		(h)
Near Bergem (Millstream)	WS	Blanket weed A	25%	g
Near Bergem (N of last)	WS	Blanket weed sp.		g
Near Noertrange (trib.)	Em	<i>Ph. arundinacea</i>		g
	WS	Blanket weed		
Bettembourg	Em	(small <i>Glyceria</i> sp., <i>Ph. arundinacea</i>)	25%	g
	WS	<i>Pot. pectinatus</i> Blanket weed		
Hesperange	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp. <i>Ph. arundinacea</i> (yellow)	60%	g
	WS	<i>Pot. pectinatus</i> A.		
Itzigersté	Em	<i>Ph. arundinacea</i> ?, Grass sp.	40%	g
	WS	<i>Pot. pectinatus</i> A, Blanket weed		
Luxembourg N2	Em	<i>Agr. stolonifera</i>	50%	g
	WS	<i>Pot. pectinatus</i> A, Blanket weed		
Clausen	Em	<i>Agr. stolonifera</i> , <i>Butomus umbellatus</i> <i>Sparganium erectum</i>	100%	e
	WS	<i>Pot. pectinatus</i> A, Blanket weed		
Dommeldange	WS	<i>Pot. pectinatus</i> A, Blanket weed	-40%	g-
Walferdange to Mullendorf	Em	<i>Ph. arundinacea</i> (flaccid)	40%	g
	WS	<i>Pot. pectinatus</i> , Blanket weed A		
Upstr. Lintgen	Em	<i>Agr. stolonifera</i>	70%	g-
	WS	<i>Pot. pectinatus</i> A, Blanket weed		
Mersch (center)	WS	<i>Pot. pectinatus</i> A, Blanket weed	50%	g-
Dstr Mersch	Em	(<i>Ph. arundinacea</i>)	40%	g-
	WS	<i>Pot. pectinatus</i> A, Blanket weed A		
Moesdorf	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> (flaccid)	40%	g
	WS	<i>Pot. pectinatus</i> A, Blanket weed		
Essingen	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	40%	g-
	WS	<i>Pot. pectinatus</i> A, Blanket weed (plus moss on weir slope)		
Cruchten	Em	<i>Agr. stolonifera</i> ? (<i>Ph. arundinacea</i>)	50%	g-
	WS	<i>Pot. pectinatus</i> A, Benthic algae		
Cruchten to Colmar (trib.)	WS	Benthic algae		
Colmar	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> (land sp., yellow)	- 60%	g
	WS	<i>Pot. pectinatus</i> A, Blanket weed A		
Ettelbruck, center	Em	<i>Glyceria maxima</i> , <i>Ph. arundinacea</i>	50%	g
	WS	<i>Pot. pectinatus</i> A, Blanket weed A		

Agr. = *Agrostis*; *Ph.* = *Phalaris*; *Pot.* = *Potamogeton*.

1. R. ALZETTE



+ near 1985 site

The patterning shows upstream sites with few species. (*P. pectinatus* does not occur in small shallow streams), but with very toxic water producing poisoned vegetation on the bank a little above normal water level (there being a "toxic line" below which bank vegetation is seriously affected). Further downstream the basic pattern of *Phalaris arundinacea* - *P. pectinatus* - Blanket weed becomes established. Other species increase far from sewage works. Frequently a toxic line occurs just downstream of sewage works.

This river has plenty of vegetation, but its type is such as to indicate severe organic (and industrial) pollution. (One toxic inflow from a factory in Dommeldange was sufficient to eliminate the *P. pectinatus* beside the inflow. The species returned as the effluent became diluted.)

The Alzette is grossly polluted by point-source toxins (sewage treatment works, factories etc). The best pollution index recorded is E (on a scale from A to H) and most sites are G or lower. The upstream sites with the E index are unreliable and probably substantially worse than this. No pollution from farmland, whether herbicide or fertiliser, could be expected to show in such a river. All such pollution would be overridden by the organic and industrial waste.

2. The river ATTERT

The Attert is a much smaller river than the Alzette. It runs through lowland farmland and flows into the Alzette. The river rises in Belgium and receives both village and road pollution before crossing the frontier. Villages are closely spaced, providing effluent at frequent intervals. Farm waste entries are also frequent and there are factories in and near the downstream villages.

Only four sites were recorded in 1977 and although a slight improvement is shown between then and 1985, it is too small to be provable on so few sites.

Grassland occurs beside the river for most of its length, though maize and cereals are also found. The Attert has an unusually unstable bed which frequently moves during higher flows and it has slumping banks. Rooted plants are therefore also unstable. Where two reducing factors are present (in this case pollution and an unstable bed) the effects are cumulative. Pollution leads to diminished anchorage (Haslam 1978, 1987), and so to enhanced damage from substrate movement. Because of this a plus sign has been added to each of the provisional pollution indices in the Table. That is, a site with an index of E+ might well, with the same pollution but with a stable substrate, have improved vegetation and an index of D, C, or perhaps even B.

The effect of the unstable bed is shown in the nature of the species present. There are no abundant rooted species growing across the channel. The species present are mainly edge emergents or (non-rooted) mosses and algae. Water-supported angiosperms are few and sparse. They are mostly

semi-eutrophic to eutrophic in nutrient preference and were absent from the downstream sites recorded. Cyanide and heavy metals have been among the industrial pollutants in these lower reaches.

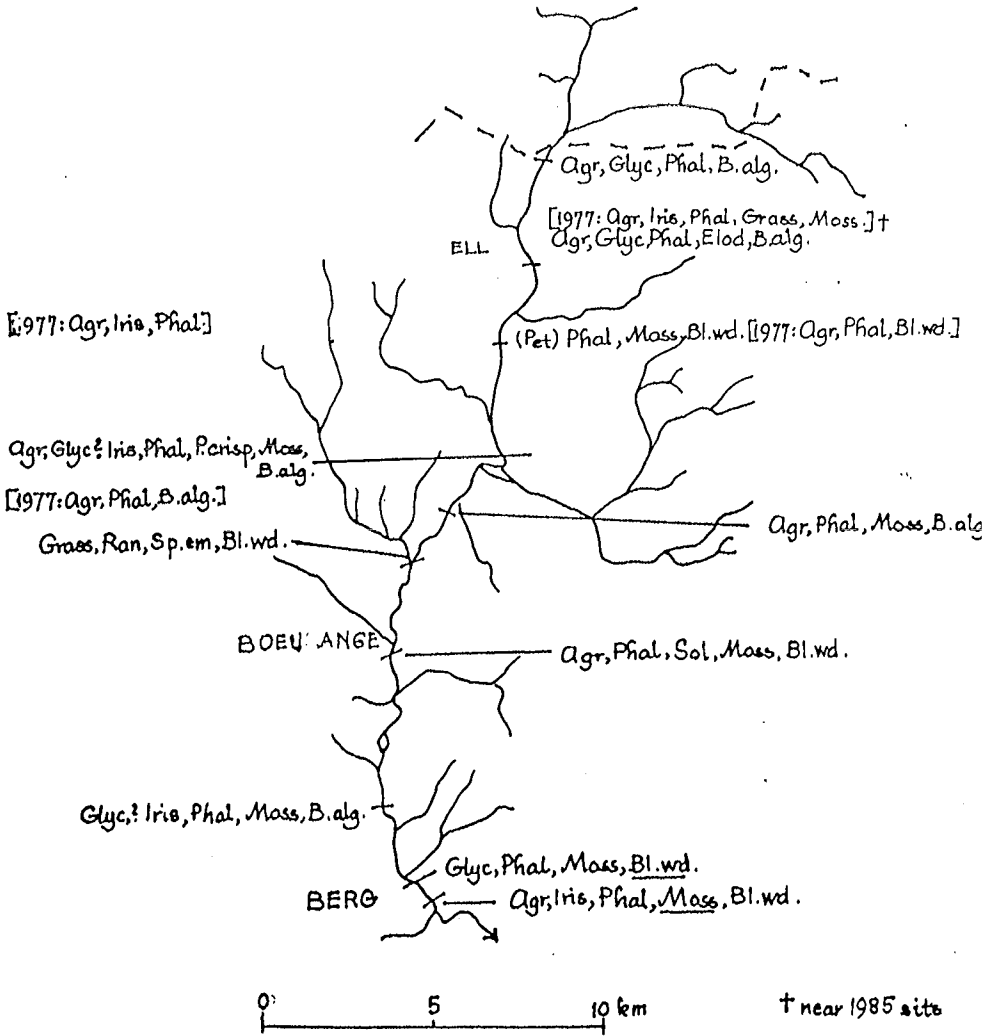
As in the Alzette, the pollution, together with the extra damage caused by the unstable channel, is sufficient to mask any damage to the vegetation from herbicides. There is a suggestion of inorganic eutrophication (excess inorganic nutrients) in the presence of for example *Potamogeton crispus* in the upper half of a small non-clay river, but the records are inadequate to prove this. If true, the increased nutrients could come from either of both of sewage etc and fertiliser, with the former being more probable. The vegetation pattern in the Attert is very different to that of the Alzette. The Attert bears few but better-quality species, and has a very low cover. The Alzette has abundant vegetation, mainly composed of pollution-favoured species. The Attert is often deep enough for *Potamogeton pectinatus*, and is trough-out deep enough for abundant Blanket weed. The interpretation is complicated by the unstable substrate. It could be that this alone is preventing the

2. RIVER ATTERT

SITE		SPECIES	COVER	DAMAGE RATING
By frontier	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp. <i>Ph. arundinacea</i>		f
	WS	Benthic algae		
E11	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp.		e
	WS	<i>Elodea canadensis</i> , brown Benthic algae		
Rédange	Em	(<i>Petasites hybridus</i>), <i>Ph. arundinacea</i>		f
	WS	Moss, Blanket weed		
Reichlange trib.	Em	small <i>Glyceria</i> sp. A	100%	-
Reichlange	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp? <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>		d
	WS	<i>Pot. crispus</i> , Moss, Benthic algae		
Sebes (upstr.)	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>		g
Useldange	WS	Moss, Benthic algae		
Useldange	Em	Grass		d/e
	WS	<i>Ranunculus</i> sp., <i>Sparganium emersum</i> ? (brownish) Blanket weed		
Boevange	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> <i>Solanum dulcamara</i> (yellow)		e
	WS	Moss, Blanket weed, Brown bottom algae		
Bissen	Em	small <i>Glyceria</i> sp.?, <i>Iris pseudacorus</i> <i>Ph. arundinacea</i>		e
	WS	Moss, Benthic algae		
Upstr. Berg	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> (flaccid)	80% (open)	e
	WS	Moss, Blanket weed A		
Berg	Em	<i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> <i>Ph. arundinacea</i> (flaccid)	- 80%	d
	WS	Moss A, Blanket weed		

Agr. = *Agrostis*; *Ph.* = *Phalaris*; *Pot.* = *Potamogeton*

2. R. ATTERT



high cover of at least some species on the bed. (N.B. if much sediment is moving downstream it will damage plants on firm substrates as well as removing those on unstrable areas). It could also be that the chemical nature of the pollution is different, due to differences in the precise nature of the sewage and organic wastes entering the rivers. Further investigation into these possibilities is needed to interpret the vegetation of this river.

3. The river CLERVE

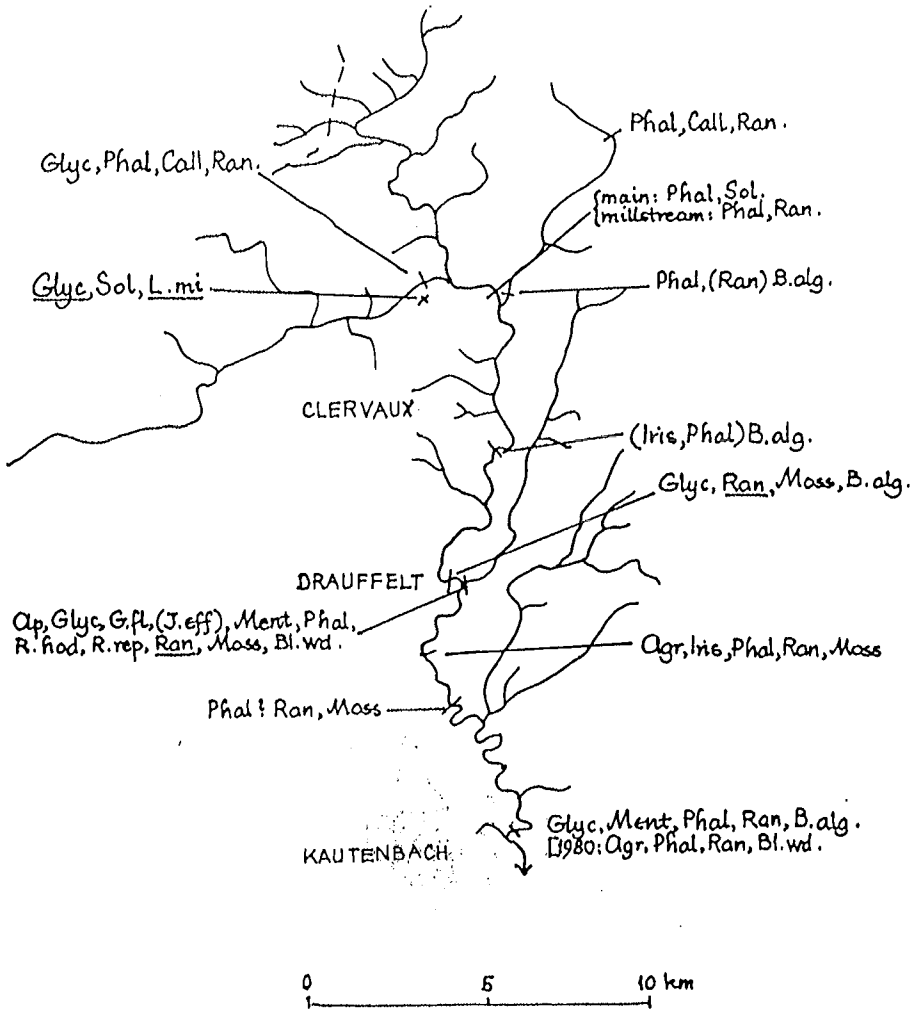
The Clerve rises on the lowland-type plateau of the north, in the part of Luxembourg in which good farming developed only in recent times. In the downstream part the settlements are richer. Near the mouth the river runs swiftly off the plateau to join the Wiltz. Throughout the catchment it is less fertile than that of the Alzette or Attert and there is little or no maize grown.

3. RIVER CLERVE

SITE		SPECIES	COVER	DAMAGE RATING
Breidfeld, trib.	Em	<i>Ph. arundinacea</i>		d
Sassel,	Ws	<i>Callitriche</i> sp., <i>Ran.</i> sp.		
r. de Troine	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> F.		c
	WS	<i>Callitriche</i> sp., <i>Ranunculus</i> sp.		
Sassel,	Em	Small <i>Glyceria</i> sp. A, <i>Sol. dulcamara</i>	100%	-
field trib.	WS	<i>Lemna minor</i> A		
Maulusmuhle,	Em	<i>Ph. arundinacea</i>		(f)
trib.				
	WS	<i>Ran.</i> sp. (far) Benthic algae		
Main	Em	<i>Ph. arundinacea</i> F, <i>Sol. dulcamara</i>		(e)
Millstr.	Em	<i>Ph. arundinacea</i>		e
	WS	<i>Ran.</i> sp.		
Dstr. Clervaux	Em	(<i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>)		g-
	WS	Benthic algae		
Drauffelt	Em	small <i>Glyceria</i> sp.	-40%	d
	WS	<i>Ran.</i> sp. A, Moss, Benthic algae		
trib.	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp.,	40%	a
Irbich		long-leaved <i>G. fluitans</i> , (<i>Juncus effusus</i>), <i>Mentha aquatica</i> , <i>Ph. arundinacea</i> , <i>Ran. hederaceus</i> , <i>Ran. repens</i>		
	WS	<i>Ran.</i> sp. A, Moss, (short) Blanket weed		
Enscherange	Em	<i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>		e
	WS	<i>Ran.</i> sp., Moss (stoned edge)		
Wilwerwiltz	Em	<i>Ph. arundinacea</i> ?		f
	WS	<i>Ran.</i> (small), Moss (wall)		
Kautenbach	Em	small <i>Glyceria</i> sp., <i>Mentha aquatica</i> , <i>Ph. arundinacea</i> , <i>Ran. repens</i>		c
	WS	<i>Ran.</i> sp., Benthic algae		

Agr. = *Agrostis*; *Ph.* = *Phalaris*; *Ran.* = *Ranunculus*; *Sol.* = *Solanum*.

3 R. CLERVE



The difference in fertility in the catchment does not, per se, influence the damage rating since the "standard"-vegetation is based on the characteristic vegetation have of the lower trophic status. The effect of domestic etc waste depends on both the population - towns as well as villages occur on the Clerve - and the quality of treatment. While this river can be used as a control catchment to assess the effects of maize cultivation (heavy applications of atrazine, etc), the differences in settlement must also be taken into account when assessing the pollutions reaching the stream and their effects on the macrophytes.

Only one site on the Clerve was recorded previously and this was in a village in a hill reach where vegetation would be low anyway. The diversity was higher in 1985, but little can be deduced from a single site in a wet summer (when fragments of emergents would have been washed downstream).

The only high-quality site recorded in 1985 was on a tributary of this river, the Irbich. The site was a considerable distance from the next upstream settlement. This undamaged plant community is oligomesotrophic in nature. It follows that the other sites are damaged, with reduced diversity, reduced nutrient-poor species and usually reduced cover. The river demonstrates the effect of sewage etc pollution on vegetation. Vegetation is usually more sensitive to mild organic pollution than are invertebrates.

The indices are moderate, reflecting the type of settlement and sewage treatment.

4. The river EISCH

Although part of the lower Eisch is in a wooded valley, the river is basically a lowland one, flowing through farmland and into the Alzette at Mersch. Much of this farmland, especially that near the river, is grassland. The crops include maize and maize can occur beside (within 2 m) of the river. Settlements are dense near the sources of the river. These give much pollution damage in the upper reaches. The intermittent settlements downstream add further pollution, preventing a complete recovery.

Unfortunately the sites recorded previously are often not exactly those recorded in 1985. However, with a dozen 1978 records it is possible to compare the general state of the river between 1978 and 1985. There has been an overall improvement.

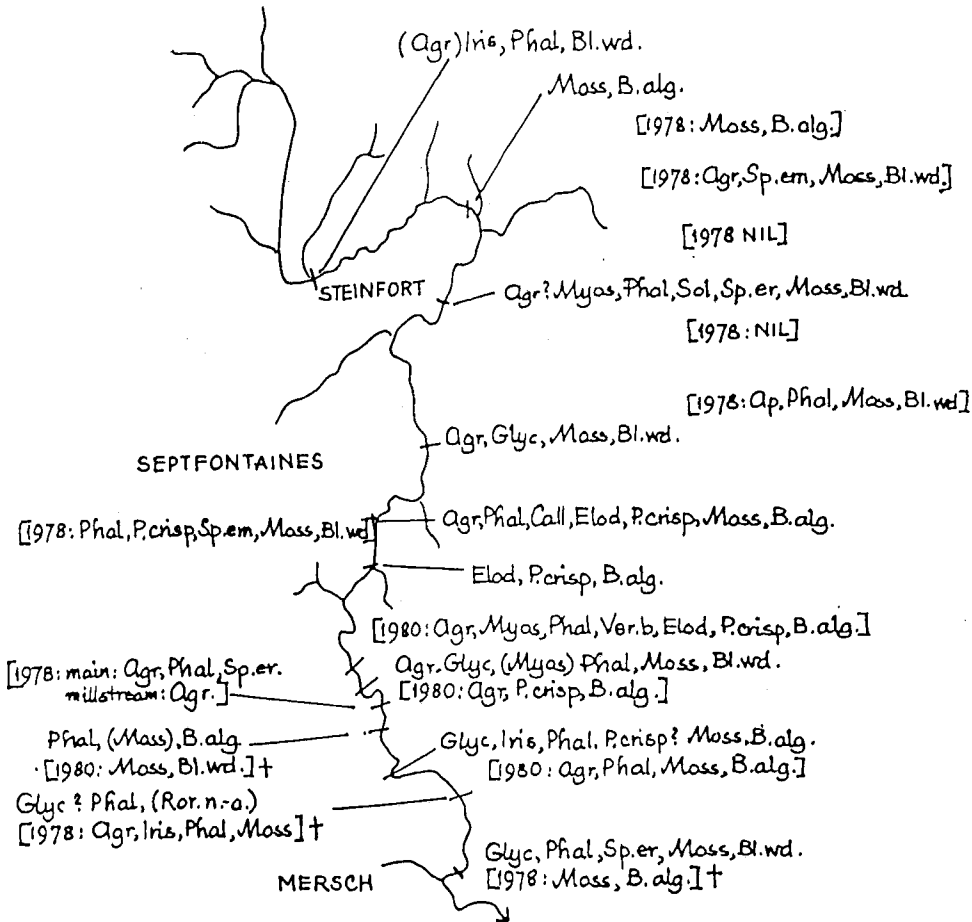
As in the Clerve, the pollution status is moderate and is mainly due to settlements. The Eisch, however, is worse near the source, due to the suitability of the land there for dense settlement. The Eisch has a central section which is possibly eutrophicated (inorganic nutrients). Unfortunately the species assemblage could also be associated with extra organic pollution. More data would be needed to elucidate this.

4. RIVER EISCH

SITE		SPECIES	COVER	DAMAGE RATING
Hagen	Em	(<i>Agr. stolonifera</i>), <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i> (flaccid)		e
	WS	Blanket weed		
Eischen	WS	Moss, long Benthic algae		g
Hobscheid	Em	<i>Agr. stolonifera</i> ?, <i>My. scorpioides</i> <i>Ph. arundinacea</i> , <i>Solanum dulcamara</i> (yellow), <i>Sparganium erectum</i>	50%	c
	WS	Moss, short brown Blanket weed		
Septfontaines	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp.		d
	WS	Moss, Blanket weed		
Roodt	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	15%	d
	WS	<i>Callitriche</i> sp, <i>Elodea canadensis</i> , <i>Pot. crispus</i> , Moss, brown Benthic algae		
Bour	WS	<i>Elodea canadensis</i> , <i>Pot. crispus</i> , Moss, brown Benthic algae		e
Marienthal	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp. (<i>My. scorpioides</i>), <i>Ph. arundinacea</i>		d
	WS	Moss, short Blanket weed		
Downstr.	Em	<i>Ph. arundinacea</i>		f/g
Marienthal	WS	Moss (splash), brown Benthic Algae		
Hunnebuer	Em	small <i>Glyceria</i> sp., <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>		d
	WS	<i>Pot. crispus</i> ?, Moss, Benthic Algae		
Reckange	Em	small <i>Glyceria</i> sp.?, <i>Ph. arundinacea</i> , (<i>Rorippa-nasturtium aquaticum</i> agg.)		e
Mersch	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> , <i>Sparganium erectum</i>		e
	WS	Moss, Blanket weed		

Agr. = *Agrostis*; *My.* = *Myosotis*; *Ph.* = *Phalaris*; *Pot.* = *Potamogeton*

4. R.EISCH



0 5 10 km

† near 1985 site

5. The river ERNZ BLANCHE

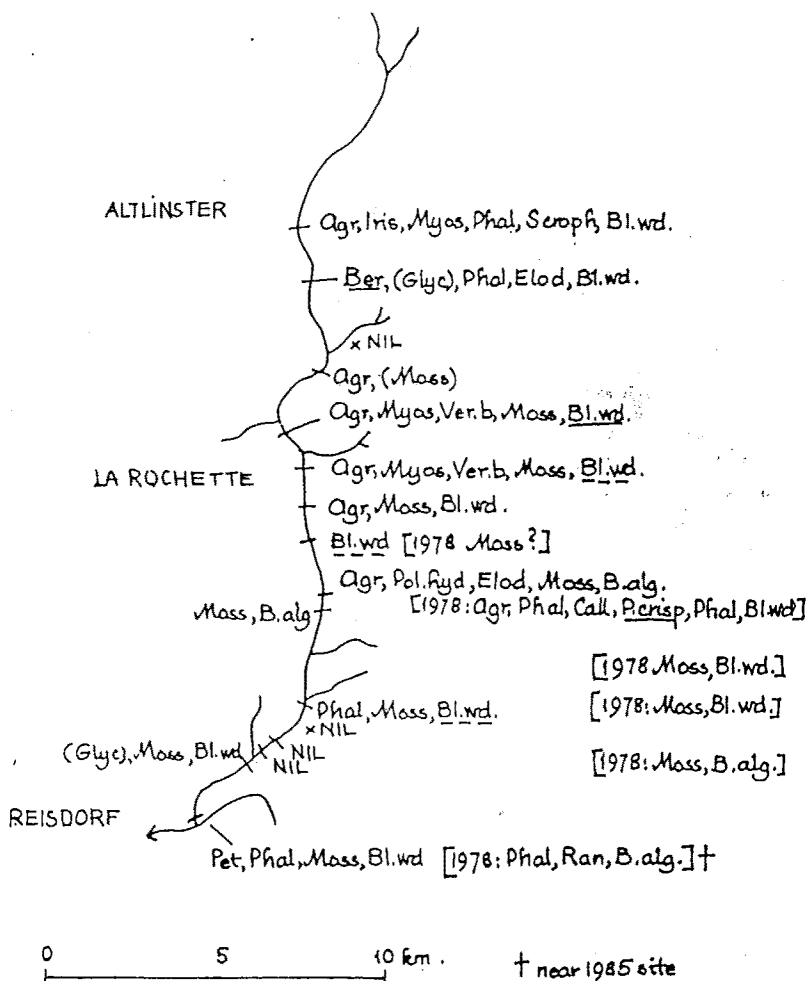
The ErnZ Blanche rises in fertile lowland farmland. In its lower reaches it flows through a woody gorge where vegetation is severely reduced both by the higher water force and by the shade. The river runs into the Sure. The upstream section has damp grassland near the river, the bed having been but little lowered (by drainage). Much of the farmland is grassland, though maize and cereals are also grown. Upstream, settlements are frequent though small. Downstream, they are larger but more separated.

5. RIVER ERNZ BLANCHE

SITE		SPECIES	COVER	DAMAGE RATING
Altlinster	Em	<i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> , <i>My. scorpioides</i> , <i>Ph. arundinacea</i> , <i>Scrophularia aquatica</i>	40%	c
	WS	Blanket weed		
Koedange	Em	<i>Berula erecta</i> A (subm.), (small <i>Glyceria</i> sp.), <i>Ph. arundinacea</i> F		d
	WS	<i>Elodea canadensis</i> , Blanket weed		
Upstr. Soup. trib.	-	(bank-shaded)		-
Soup	Em	<i>Agr. stolonifera</i>		f
	WS	Moss (splash)		
Larochette upstr.	Em	<i>Agr. stolonifera</i> , <i>Berula erecta</i> (subm.), small <i>Glyceria</i> sp., (<i>Scro. aquatica</i>), <i>Veronica beccabunga</i>		b
	WS	Moss, brown Benthic algae		
Larochette	Em	<i>Agr. stolonifera</i> , <i>My. scorpioides</i> <i>Veronica beccabunga</i>	25%	d
	WS	Moss, Blanket weed (A)		
Upstr. Medernach	Em	<i>Agr. stolonifera</i>		e
	WS	Moss, Blanket weed		
Medernach	WS	Blanket weed (A)	-40%	g
Upstr. Ermsdorf	Em	<i>Agr. stolonifera</i> <i>Pol. hydropiper</i> agg		d
	WS	<i>Elodea canadensis</i> , Moss, Benthic algae		
Ermsdorf	ES	Moss, Benthic algae		g
Neumuhle	Em	<i>Ph. arundinacea</i>	-80%	d
	WS	Moss, Blanket weed		
Dstr. Neumuhle trib.	-	(shaded)		g-
far Neumuhle trib.	-	(shaded)		g-
Hessemuhle upstr.	-	(shaded)		g-
Hessemuhle	Em	(short <i>Glyceria</i> sp.)	15%	e
	WS	Moss, Blanket weed	open	
Reisdorf	Em	<i>Petasites hybridus</i> , <i>Ph. arundinacea</i>	-40%	c
	WS	Moss, Blanket weed		

Agr. = *Agrostis*; *My.* = *Myosotis*; *Ph.* = *Phalaris*; *Pol.* = *Polygonum*;
Scro. = *Scrophularia*

5. R. ERNZ BLANCHE



Only the lower part of the river was surveyed in 1978, and there is no significant change except that the site above Ermsdorf has deteriorated. The pollution status is moderate, the vegetation being best in the parts upstream of Larochette sewage. The upstream farming settlements and the downstream larger village lead to less satisfactory river quality.

6. The river ERNZ NOIRE

The Ernz Noire also rises in fertile lowland farmland country and joins the Sure after flowing through a wooded gorge with much reduced vegetation. Currently the discharge in the gorge is low for the channel size, as source water is removed for the domestic supply system. Water force in the relevant areas is, therefore, less than would otherwise be expected. The settlement pattern is similar to that of the Ernz Blanche.

In the recorded sites there has been a slight improvement in river quality since 1978, especially upstream.

In the upstream section the plant community is good, even though at the site recorded second from the source the water is plainly severely polluted. Water force is low (drainage being little) and so pollution-weakened plants could not be easily removed by scour. This region requires further investigation to determine the exact chemical nature of the pollution. The vegetation deteriorates below Junglinster and as it recovers from that effluent it becomes reduced by the gorge habitat. The overall pollution status of the river is moderate.

7. The river MAMER

The Mamer rises in fertile lowland farmland. The large village of Garnich is sited where the stream is still only 0.5-1 m wide. The river is therefore effectively polluted from source. The position is made much worse by the Mamer sewage work, which produces exceptionally low quality effluent. The river then flows through a woody gorge, though its water force is much less than in the Ernz Blanche and Ernz Noire. It finally emerges into open farmland before joining the Alzette at Mersch.

Since 1980 the river quality has probably improved in the Kopstal region, though in the lower part the records are conflicting.

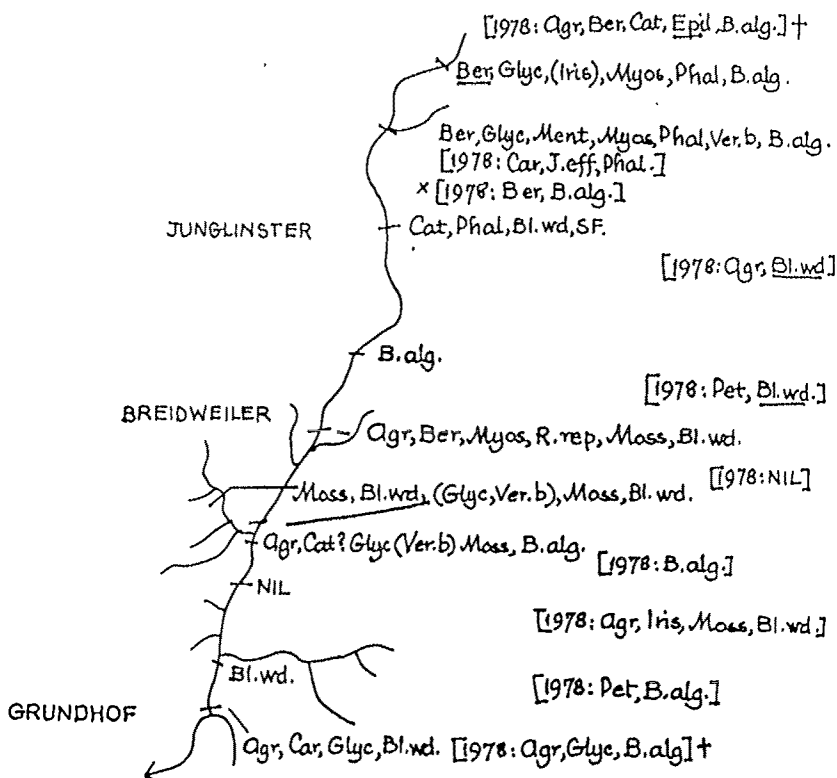
If the upper reaches of this river could be improved, satisfactory vegetation would be probable. As it is, the effect of the upstream settlements probably persists and is then added to by the more minor downstream settlements. As in the preceding rivers, there is no firm evidence of herbicide pollution.

6. RIVER ERNZ NOIRE

SITE		SPECIES	COVER	DAMAGE RATING
Ernster	Em	<i>Ber. erecta</i> A, small <i>Glyceria</i> sp. (<i>Iris pseudacorus</i>), <i>My. scorpioides</i> , <i>Ph. arundinacea</i>	-100%	(b)
	WS	brown Benthic algae		
Gonderange	Em	<i>Ber. erecta</i> , small <i>Glyceria</i> sp., <i>Mentha aquatica</i> , <i>My. scorpioides</i> , <i>Ph. arundinacea</i> (yellow) <i>Veronica beccabunga</i>		(b)
	WS	brown Bottom algae		
Junglinster (Dstr.)	Em	<i>Cat. aquatica</i> , <i>Ph. arundinacea</i>	(50%)	e
	WS	Blanket weed, sewage fungus		
Blumenthal	WS	Benthic algae		g-
Marscherwald	Em	<i>Agr. stolonifera</i> , <i>Ber. erecta</i> , <i>My. scorpioides</i> , <i>Ran. repens</i>		c
	WS	Moss, Blanket weed		
Consdorf, trib.	WS	Moss, Blanket weed		f
Near Consdorf	Em	(small <i>Glyceria</i> sp., <i>Ver. beccabunga</i>		f
	WS	Moss, Blanket weed		
Mullerthal	-			g-
Vogelsmühle	WS	Blanket weed		g
Grundhof	Em	<i>Agr. stolonifera</i> , <i>Carex</i> <i>acutiformis</i> agg., small <i>Glyceria</i> sp.	20%	e
	WS	Blanket weed		

Agr.=*Agrostis*; *Ber.*=*Berula*; *Cat.*=*Catabrosa*; *My.*=*Myosotis*;
Ph.=*Phalaris*; *Ran.*=*Ranunculus*; *Ver.*=*Veronica*

6. R. ERNZ NOIRE



0 5 10 km

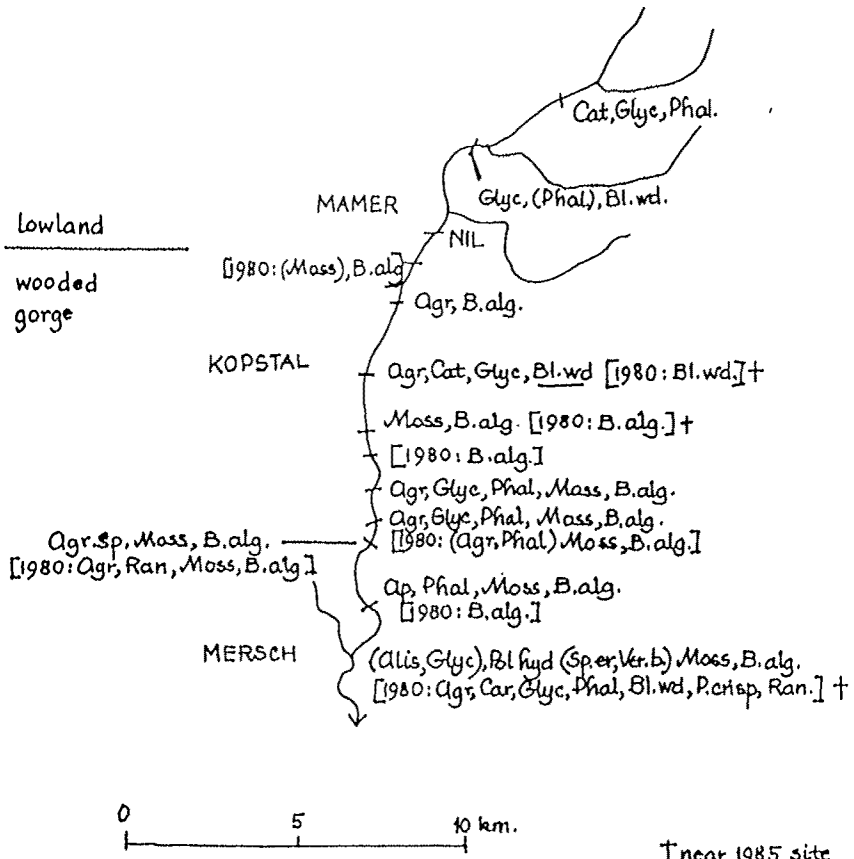
† near 1985 site

7. RIVER MAMER

SITE		SPECIES	COVER	DAMAGE RATING
Garnich	Em	<i>Cat. aquatica</i> , small		e
		<i>Glyceria</i> sp., <i>Ph. arundinacea</i>		
Holzern	Em	small <i>Glyceria</i> sp., (<i>Ph. arundinacea</i>)		f
	WS	Blanket weed		
Dstr. Mamer	-			g-
Upstr. Kopstal	Em	<i>Agr. stolonifera</i>		g
	WS	Benthic algae		
Kopstal	Em	<i>Agr. stolonifera</i> , <i>Cat. aquatica</i> , small <i>Glyceria</i> sp.	75%	e
	WS	Blanket weed A		
Direndall	WS	Brown Benthic Algae		g-
Upstr. Schoenfels	WS	Moss (splash), brown Benth. algae		f
Upstr. Schoenfels	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp., <i>Ph. arundinacea</i>		e
	WS	Moss, brown Benthic algae		
Dstr. Schoenfels	Em	<i>Agr. stolonifera</i>		
	WS	Trailing species, Moss, Benthic algae		
Upstr. Mersch	Em	<i>Apium nodiflorum</i> ?, <i>Ph. arundinacea</i>		e
	WS	Moss, brown Benthic algae		
Mersch	Em	(<i>Al. plantago-aquatica</i> , small <i>Glyceria</i> sp., <i>Pol. hydropiper</i> agg., <i>Sparg. erectum</i> , <i>Veronica beccabunga</i>)		c
	WS	Moss, long Benthic algae		

Agr. = *Agrostis*; *Al.* = *Alisma*; *Cat.* = *Catabrosa*;
Ph. = *Phalaris*; *Pol.* = *Polygonum*; *Sparg.* = *Sparganium*

7. R. MAMER



8. The river OUR

The Our rises in the Ardennes and flows to the Sure. The combination of considerable water force due to a steep landscape, unstable substrate and, on the day of record, high turbidity, make the interpretation of pollution status uncertain.

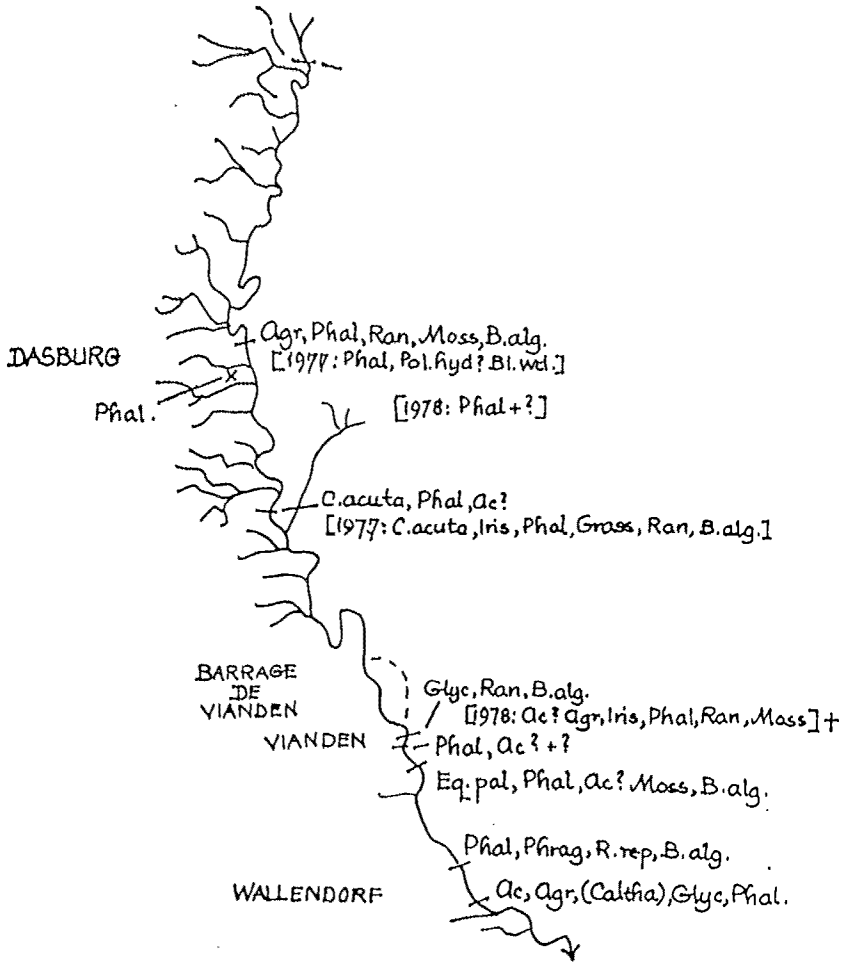
Change between 1977/78 and 1985 cannot be proved. It seems likely that there is some pollution damage but more site records and more information about bed instability would be needed to assess this with any accuracy.

8. RIVER OUR

SITE		SPECIES	COVER	DAMAGE RATING
Dasburg	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>		e/f
	WS	<i>Ran. sp.</i> , Moss (concrete), Benthic algae		
S of Dasburg trib.	Em	<i>Ph. arundinacea</i>		-
Untereisenbach	Em	<i>Carex accuta</i> agg., <i>Ph. arundinacea</i> , <i>Sparganium erectum</i> ? (or <i>Acorus</i>)		f
Vianden, dstr.	Em	small <i>Glyceria sp.</i>		f
	WS	<i>Ran. sp.</i> , Benthic algae		
Vianden dstr. STW	Em	<i>Ph. arundinacea</i> F, <i>Sparganium erectum</i> ? (or <i>Acorus</i>)		f?
Bettel	Em	<i>Equisetum palustre</i> , <i>Ph. arundinacea</i> , <i>Sparganium erectum</i> ? (or <i>Acorus</i>)		d
	WS	Moss (splash), brown Benthic algae		
Hoesdorf	Em	<i>Ph. arundinacea</i> , <i>Phragmites communis</i> , <i>Ran. repens</i>		e
	WS	Benthic algae		
Upstr. Wallendorf	Em	<i>Acorus calamus</i> , <i>Agr. stolonifera</i> , (<i>Caltha palustris</i>), small <i>Glyceria sp.</i> , <i>Ph. arundinacea</i>		d

Agr. = *Agrostis*; *Ph.* = *Phalaris*; *Ran.* = *Ranunculus*

8. R.OUR



0 5 10 km

† near 1985 site

9. The river SURE

The Sure rises in the Ardennes in Belgium where it is relatively clean until around the frontier at Martelange. It continues flowing through upland country with a large reservoir above Esch/Sure. Downstreams of this reservoir the water level is liable to fluctuations from the working of the barrage. Such large variations in water level - and in hill country also in water force - can influence vegetation. The influence will be most closest to the reservoir. This is because the effects are more sudden (not damped down) and because the river is shallower, so a 0.5 m increase in level may more than double the depth. Downstream the proportional increase will be much less. Variations in water force due to the barrage will be accompanied by variations in bed stability. Besides, as the water flows out at the bottom of the reservoir, a decrease of the mean temperature of the Sure downstreams of Esch/Sure is expectable.

The middle part of the river flows through lowland farming country and the lower part is in a wide gorge which, however, does not cause much extra water force. Near the mouth there is a second barrage at Rosport but, because the river is so much larger here and the bed gradient is less, it has much less effect on the river habitat than does the Esch reservoir.

The Sure has moderate pollution in Martelange, from effluents upstream. Comparing the previous and 1985 records, there is little change in Martelange but the damage done by Martelange sewage has lessened. *Ranunculus* has possibly decreased below Esch (different sites?). Below the confluence with the polluted Alzette the community is now more diverse. There is little change in pollution status because pollution-favoured species have increased. The influence of the Alzette is shown in lowered indices, abundant *Potamogeton pectinatus* etc. This influence slowly decreases downstream but is still noticeable down to the confluence of the (cleaner) Ernzt Blanche and Our. Because the water level was high on the day of record from the opening of the barrage, it was not possible to obtain satisfactory records between Heiderscheidergrund and Ettelbruck. It seems possible, however, that *Ranunculus* is decreasing. (For more detail see work of Claudine Wolff, 1987).

In the lower part of the river sparse *Ranunculus* was recorded once in 1980. It was certainly absent from three sites recorded in 1978 and 1980 and may be absent from five (the other two records being incomplete). The 1985 recorded vegetation shows a diverse, slightly polluted, fairly eutrophic community, many sites having an index of B with no *Ranunculus*.

A main cause of complaint is the loss of *Ranunculus* or equivalent species in this part. The barrage has altered waterforce and substrate. Tourism (boating, camping, paddling etc) has increased disturbance also. *Ranunculus* is the species most usually favoured by anglers who feel it contributes best to the well being of fish. In most of the recorded sites in the lower section of the Sure, diversity is adequate and cover, if not high, is enough to support invertebrates. With such a nutrient-rich flora, abundant *Ranunculus* would be unusual. The nutrient status, however, could be due to eutrophic pollution (in which case all indexes should be 1-2 grades lower). In this

9. RIVER SURE

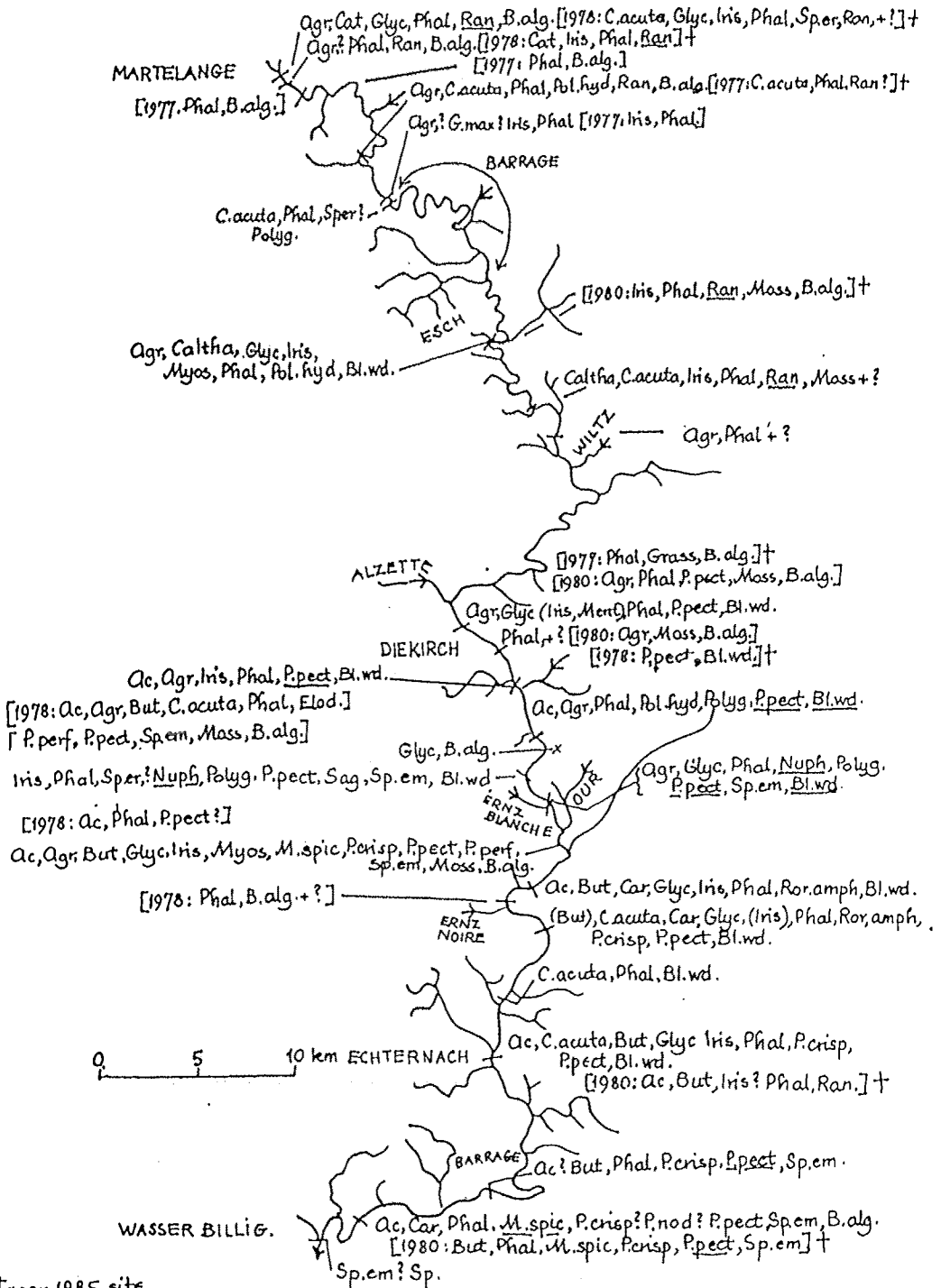
SITE		SPECIES	COVER	DAMAGE RATING
Martelange upstr.	Em	<i>Agr. stolonifera</i> , <i>Cat. aquatica</i> , small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> (<i>Alisma plantago-aquatica</i> recently)	~40%	c
	WS	<i>Ran. sp. A</i> , Benthic algae		
Martelange dstr.	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i>	10%	e
	WS	<i>Ranunculus</i> sp., Benthic algae		
Bigonville	Em	<i>Agr. stolonifera</i> , <i>Carex acuta</i> agg <i>Ph. arundinacea</i> , <i>Pol. hydropiper</i> agg		c
	WS	<i>Ranunculus</i> sp., Benthic algae		
Pont Misère	Em	<i>Agr. stolonifera</i> ?, <i>Glyceria maxima</i> ? <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>		(e?)
Pont Misère, dstr	Em	<i>Carex acuta</i> agg., <i>Ph. arundinacea</i> <i>Sparganium erectum</i> ?		(e?)
	WS	<i>Polygonum amphibium</i>		
Heiderscheider- grund	Em	<i>Agr. stolonifera</i> , <i>Caltha palustris</i> , small <i>Glyceria</i> sp., <i>Iris pseudacorus</i> , <i>Myo. scorpioides</i> , <i>Ph. arundinacea</i> , <i>Pol. hydropiper</i> agg.		(c)
	WS	Blanket weed		
Tadler Moulin	Em	<i>Caltha palustris</i> , <i>Carex acuta</i> agg., <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>	30%	(b)
	WS	<i>Ranunculus</i> sp. A, Moss and ?		
Dirbach	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> and ?		(g)
Ingeldorf	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp., (<i>Iris pseudacorus</i> , <i>Mentha aquatica</i>) <i>Ph. arundinacea</i>	~40%	e
	WS	<i>Pot. pectinatus</i> , Blanket weed (A)		
Diekirch	Em	<i>Ph. arundinacea</i> and ?		(h)
Gilsdorf dstr.	Em	<i>Acorus calamus</i> , <i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>	40%	(d)
	WS	<i>Pot. pectinatus</i> , Blanket weed A		
Bettendorf	Em	<i>Acorus calamus</i> , small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> , <i>Pol. hydropiper</i> agg.,	~80%	c?
	WS	<i>Pol. amphibium</i> , <i>Pot. pectinatus</i> A Blanket weed A		
Bettendorf trib.	Em	small <i>Glyceria</i> sp.		g
	WS	Benthic algae		
Moestroff	Em	<i>Iris pseudacorus</i> , <i>Ph. arundinacea</i> , <i>Sparganium erectum</i> ? (subm)	60%	a/b
	WS	<i>Nuphar lutea</i> A, <i>Pol. amphibium</i> , <i>Pot. pectinatus</i> , <i>Sagittaria sagittifolia</i> , <i>Sparganium emersum</i> (and emerged), Blanket weed		
Reisdorf	Em	<i>Agr. stolonifera</i> , short <i>Glyceria</i> sp., <i>Ph. arundinacea</i>	50%	d
	WS	<i>Nuphar lutea</i> A, <i>Pol. amphibium</i> , <i>Pot. pectinatus</i> A, <i>Sparganium emersum</i> Blanket weed A		

Wallendorf	Em	<i>Acorus calamus</i> F, <i>Agr. stolonifera</i> , 30% <i>But. umbellatus</i> F, small <i>Glyceria</i> sp., <i>Iris pseudacorus</i> , <i>Myo. scorpioides</i> , <i>Ph. arundinacea</i> F	c
	WS	<i>Myriophyllum spicatum</i> , <i>Pot. crispus</i> , <i>Pot. pectinatus</i> , <i>Pot. perfoliatus</i> , <i>Sparganium emersum</i> , Moss Benthic algae	
Dillingen	Em	<i>Acorus calamus</i> , <i>But. umbellatus</i> , <i>Carex acutiformis</i> agg., small <i>Glyceria</i> sp., <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i> , <i>Rorippa amphibia</i>	b
	WS	Blanket weed	
Bollendorf	Em	(<i>Butomus umbellatus</i>), <i>Carex acuta</i> agg., <i>Carex acutiformis</i> agg., small <i>Glyceria</i> sp., (<i>Iris pseudacorus</i>), <i>Ph. arundinacea</i> F, <i>Rorippa amphibia</i> ,	b
	WS	<i>Pot. crispus</i> , <i>Pot. pectinatus</i> , Blanket weed	
Weilerbach	Em	<i>Carex acuta</i> agg., <i>Ph. arundinacea</i>	f
	WS	Blanket weed	
Echternach	Em	<i>Acorus calamus</i> , <i>But. umbellatus</i> , <i>Carex acuta</i> agg., small <i>Glyceria</i> sp., <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i> F	b
Rosport	WS	<i>Pot. crispus</i> , <i>Pot. pectinatus</i> Blanket weed	
	Em	<i>Acorus calamus</i> ?, <i>But. umbellatus</i> , 40% <i>Ph. arundinacea</i>	d
	WS	<i>Pot. crispus</i> , <i>Pot. pectinatus</i> A, <i>Sparganium emersum</i>	
Langsur upstr.	Em	<i>Acorus calamus</i> , <i>Carex acutiformis</i> agg., <i>Ph. arundinacea</i>	b
	WS	<i>Myriophyllum spicatum</i> (A), <i>Pot. crispus</i> ?, <i>Pot. nodosus</i> ?, <i>Pot. pectinatus</i> , <i>Sparganium emersum</i> , Benthic algae	
Wasserbillig	WS	<i>Sparganium?</i> <i>emersum</i> sp.	g+

Agr.=*Agrostis*; *But.*=*Butomus*; *Cat.*=*Catabrosa*; *Myo.*=*Myosotis*;
Ph.=*Phalaris*; *Pol.*=*Polygonum*; *Pot.*=*Potamogeton*

rapid survey it was not possible to investigate the point. However, the vegetation pattern suggests that the *Ranunculus* was not in its preferred habitat and, if it has declined, it succumbed through long-continued weakening. It is possible that a change in flow type would lead to the reappearance of *Ranunculus*. It is also possible that transplants into places with fast flow, stable substrates and a depth of about 1 m might be successful. Without further investigation it is not possible to say whether herbicide could have been partly or wholly responsible for the loss in *Ranunculus*. It is not impossible but no evidence is available and the loss can plausibly be explained in terms of other habitat factors. The rest of the vegetation remains adequate. The proven sources of pollution are organic etc wastes and the Alzette seriously polluted with organic and industrial wastes.

9. R. SURE



Tnear 1985 site.

10. The river SYR

The Syr, like the Ernzt Blanche and Ernzt Noire, rises in fertile lowland farmland and has its lower reaches in a wooded gorge where the vegetation is much reduced. However, only a small proportion of the river is in the gorge. Three tributaries were recorded, all in lowland farmland, because samples had been taken from these streams for atrazine analysis. While grass occupies much of the (open) part of the catchments, cereals, maize etc occur also, and maize-fields may adjoin the streams. The upper Syr has unstable banks, like the Alzette and Attert, but the bed is not as unstable as that of the Attert.

Settlements are frequent along the river and effluent from the sewage treatment works usually lowers the index by about one grade. As in the rest of Luxembourg, organic waste reaches the river directly as well as through sewage works.

The river is polluted near the source. The vegetation improves downstream and then deteriorates again. This pattern is repeated along the river, the drops being determined by the point source of pollution. The sites recorded in both 1980 and 1985 often show a difference in cover, in a way indicating deterioration. Either the abundance of pollution-favoured species has increased, or the abundance of other species has decreased. Diversity has slightly increased in the upper section and slightly decreased in the central section. The conclusion is that, on balance, the river vegetation is marginally worse.

The indices indicate moderate pollution overall. The highest index recorded is B, but most are lower. The three tributaries, Boudlerbach, Berbourgach and Lelligbach, have similar pollution levels to the main river. Naturally in smaller streams effluents are diluted less so the total amount of pollutants needed to lower the index is less. The comparative amounts of pollution in the river and tributaries are similar.

The species assemblages in the tributary sites are those characteristic of sites polluted by organic wastes. However, the assemblages could also be consistent with herbicide pollution. Water-supported angiosperms (such as *Elodea canadensis* or *Potamogeton crispus*) are almost absent. Blanket weed is frequent and most angiosperms present are tough ones like tall monocotyledons (e.g. *Phalaris arundinaceae*), or semi-ephemerals like edge grasses (e.g. *Agrostis stolonifera*). The worst reaches are associated with settlements and not with maize fields, either beside the river or further off in the catchment. It is therefore presumed that organic waste is the principal cause of damage to the plants but extra damage from herbicides cannot be excluded. In the main river the changes are more obviously associated with settlements.

Near the base of the Syr, factories cause increased pollution which is reflected in the low index of E.

10. RIVER SYR

SITE		SPECIES	COVER	DAMAGE RATING
Upstr. Syren	Em	<i>Ph. arundinacea</i>	30%	f
	WS	Blanket weed		-
Upstr. Syren trib.	Em	<i>Ph. arundinacea</i>		
Dstr. trib	Em	<i>Agr. stolonifera</i> , <i>Berula erecta</i> ?	15-20%	(e)
		<i>Ph. arundinacea</i>		
	WS	Benthic algae		
Syren	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>		f
Dstr. Syr (Main)	Em	<i>Ph. arundinacea</i> A	100%	-
Millstr.	Em	<i>Agr. stolonifera</i> , <i>Myosoton</i> <i>aquaticum</i> , <i>Ph. arundinacea</i> , <i>Rorippa nasturtium-aquaticum</i> agg.	50%	b
	WS	<i>Callitriche</i> sp. A, Blanket weed		
Medingen trib.	Em	<i>Agr. stolonifera</i>		(g-)
Medingen	Em	<i>Ph. arundinacea</i>	25%	d
	WS	<i>Callitriche</i> sp., Blanket weed		
Dstr. Medingen	Em	<i>Ph. arundinacea</i>		e
	WS	<i>Callitriche</i> sp.		
Moutfort	Em	<i>Agr. stolonifera</i> , <i>Ber. erecta</i> (subm.)	20%	c
		<i>Myo. scorpioides</i> , <i>Ph. arundinacea</i>		
	WS	<i>Callitriche</i> sp., Blanket weed		
Oetrage	Em	(<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>)	25%	g
		Blanket weed A		
Schrassig	Em	<i>Agr. stolonifera</i> , (<i>Ph. arundinacea</i>)		g
	WS	Blanket weed		
Schrassig upstr.	WS	Blanket weed		g
Airport trib.				
Schrassig dstr.	Em	<i>Agr. stolonifera</i> , <i>Berula erecta</i>	20%	b
Airport trib.		<i>Iris pseudacorus</i> , <i>Mentha aquatica</i> , <i>Ph. arundinacea</i> , <i>Ran. repens</i> , (<i>Urtica dioica</i> , yellow)		
	WS	<i>Callitriche</i> sp., Blanket weed		
Ubersyren	Em	<i>Agr. stolonifera</i> , <i>Myo. scorpioides</i>	25%	c
		<i>Ph. arundinacea</i> , <i>Veronica beccabunga</i>		
	WS	<i>Elodea canadensis</i> , Blanket weed A		
Ubersyren dstr. STW	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	70%	d
	WS	<i>Callitriche</i> sp., <i>Elodea canadensis</i> , Blanket weed		
Munsbach	Em	<i>Agr. stolonifera</i> , <i>Mentha aquatica</i> , <i>Ph. arundinacea</i>	-80%	c
	WS	<i>Elodea canadensis</i> , Moss? Blanket weed A		
Roodt	Em	<i>Agr. stolonifera</i>	50%	e
	WS	Blanket weed A		
Olingen	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	60%	e
	WS	<i>Zannichellia palustris</i> , Blanket weed A		
Betzdorf	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> , <i>Solanum dulcamara</i> (yellow)	70%	c
	WS	<i>Zanichellia palustris</i> , Moss, <i>Enteromorpha</i> sp., Blanket weed A		
Hagelsdorf	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> , <i>Sparganium erectum</i> ((subm.)	40%	d
	WS	<i>Pot. pectinatus</i> A, Moss, Blanket weed A		

Wecker, dstr.	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	20%	f
	WS	<i>Pot. pectinatus</i> , Blanket weed A		
Dstr. Wecker STW	Em	<i>Agr. stolonifera</i>		e
	WS	<i>Callitriche</i> sp., <i>Zanichellia palustris</i> , <i>Benthic algae</i>		
Manternach, upstr. Mill	Em	<i>Agr. stolonifera</i> , <i>Myo. scorpioides</i>	10%	e
	WS	<i>Zanichellia palustris</i> , <i>Enteromorpha</i> sp. Blanket weed		
Manternach, dstr. Mill	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> ,	30%	c
	WS	Grass Moss, Blanket weed		
Dstr. Syr confl. Lellig	Em	<i>Agr. stolonifera</i> , <i>Myo. scorpioides</i>	-50%	d
	WS	<i>Ph. arundinacea</i> , Grass Moss, Blanket weed		
Mertert	Em	(<i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>)	15%	e
	WS	<i>Pol. hydropiper</i> agg. Moss, Benthic algae		

Boudlerbach tributary

SITE		SPECIES	COVER	DAMAGE RATING
Upstr. Boudler	Em	<i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>	20%	(e)
	WS	Blanket weed		
Nr Boudler	Em	<i>Agr. stolonifera</i> , (<i>Iris pseudacorus</i>), <i>Ph. arundinacea</i>		(g)
Nr Boudler, Eschweiler trib.	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>	50%	b
	WS	<i>Ran. repens</i> , <i>Veronica beccabunga</i> Moss, Blanket weed A		
Nr Boudler	Em	<i>Agr. stolonifera</i>		(g)
Biwer	WS	Blanket weed A	50%	g
Wecker	Em	<i>Agr. stolonifera</i> Blanket weed		g

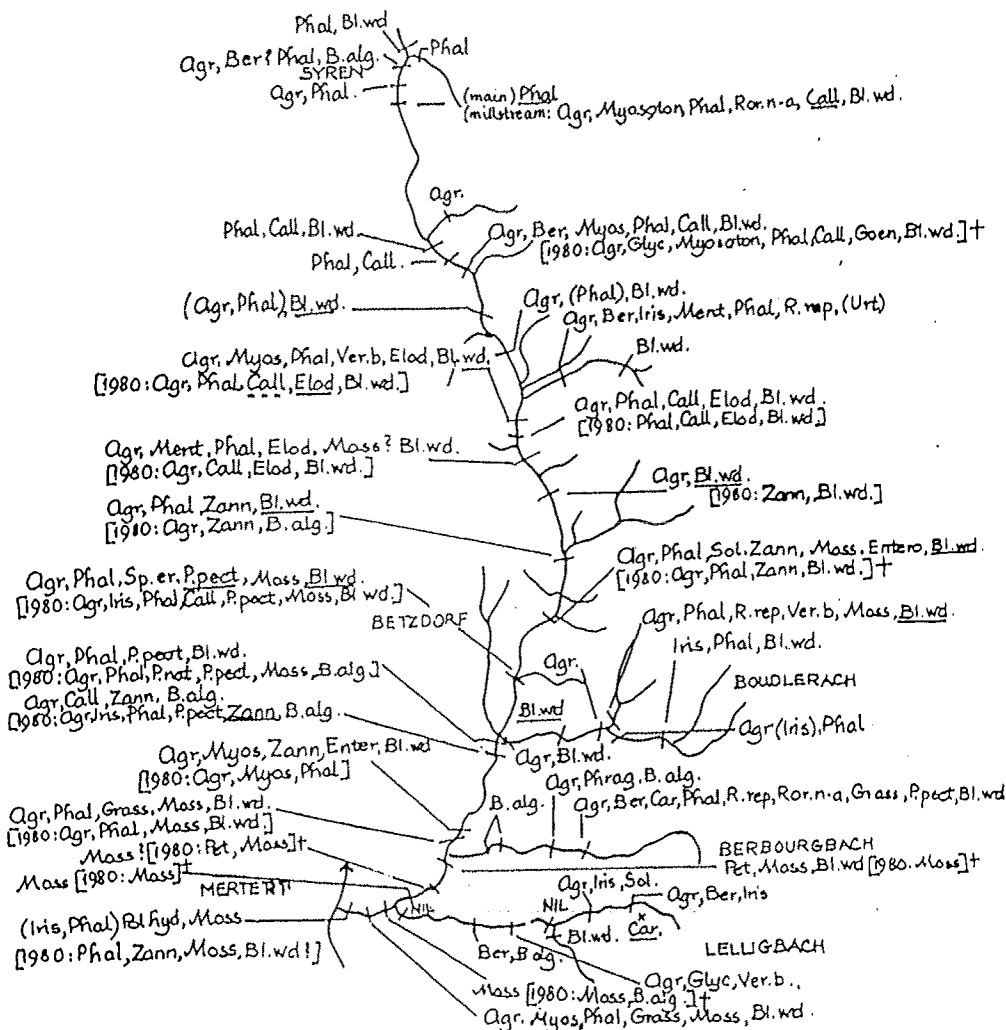
Berbourgbach tributary

Berbourg	Em	<i>Agr. stolonifera</i> , <i>Berula erecta</i> ? <i>Carex acutiformis</i> agg., <i>Ph. arundinacea</i> (yellow), (<i>Ran. repens</i>), <i>Rorippa</i> <i>nasturtium-aquaticum</i> agg., Grass	25%	c
	WS	<i>Pot. pectinatus</i> , Blanket weed		
Dstr. Berbourg	Em	<i>Agr. stolonifera</i> , <i>Phragmites communis</i>		f
	WS	Benthic algae		
Far dstr. Berbourg	WS	Benthic algae		g-
Just dstr. Berb.	WS	Benthic algae		g-

Lelligbach tributary

Upstr.	Em	<i>Agr. stolonifera</i> , <i>Berula erecta</i> (?) <i>Iris pseudacorus</i>		d
trib. by site	Em	<i>Carex acutiformis</i> A	-100%	-
Dstr. last	Em	<i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> , <i>Solanum dulcamara</i>		d
Dstr. last	-			g-
Dstr. last, trib. by site	WS	Blanket weed	20%	g
Upstr. Lellig	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp., <i>Veronica beccabunga</i>		(d)
Lellig	Em	<i>Berula erecta</i> (?)		(g)
	WS	Benthic algae		
At Syr confl.	WS	Moss, Benthic algae		g

10. SYR



0 5 10 km

† near 1985 site

11. The river WILTZ

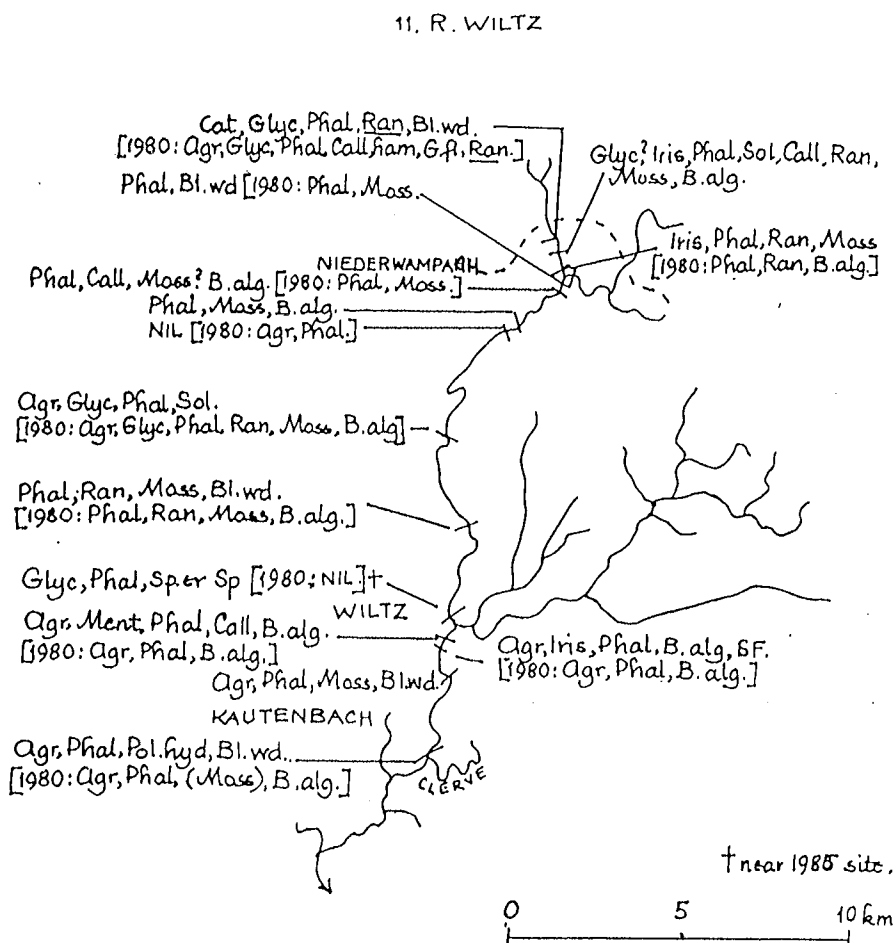
The Wiltz rises on the Ardennes plateau in Belgium and soon flows into Luxembourg. Near the frontier the gradient is still low (though the landscape is more upland). The landscape becomes steeper and then mountainous downstream, the river habitat becoming that of a hill stream. In this section pollution indices are difficult to assess. Settlements are sparse along the river but the main town of Wiltz is industrial as well as fairly large. The river flows into the Sure.

11. RIVER WILTZ

SITE		SPECIES	COVER	DAMAGE RATING
Near frontier	Em	<i>Cat. aquatica</i> , small <i>Glyceria</i> sp. <i>Ph. arundinacea</i>	60%	b
	WS	<i>Ranunculus</i> sp. A. Blanket weed		
Upstr.	Em	small <i>Glyceria</i> sp.?, <i>Iris pseudacorus</i> , <i>Ph. arundinacea</i> , <i>Solanum dulcamara</i>	20%	b
Niederwampach	WS	<i>Callitriche</i> sp., <i>Ran.</i> sp., Moss, Benthic algae		
Niederwampach	Em	<i>Iris pseudacorus</i> , <i>Ph. arundinacea</i>	10%	c
	WS	<i>Ranunculus</i> sp., Moss		
Niederwampach	Em	<i>Ph. arundinacea</i>		e
trib.	WS	Blanket weed		
Niederwampach	Em	<i>Ph. arundinacea</i>		d
below confl.	WS	<i>Callitriche</i> sp., Moss? Benthic algae		
Upstr. Schleif	Em	<i>Ph. arundinacea</i>		e
	WS	Moss, Benthic algae		
Schleif	-			g-
Winseler dstr.	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp. <i>Ph. arundinacea</i> , <i>Solanum dulcamara</i> <i>Ranunculus</i>	10%	c
	WS			
Mill,	Em	<i>Ph. arundinacea</i>		d
upstr. Wiltz	WS	<i>Ranunculus</i> sp., Moss, Blanket weed		
Wiltz	Em	small <i>Glyceria</i> sp., <i>Ph. arundinacea</i> <i>Sparganium erectum</i> , sp	10%	b
	WS	<i>Callitriche</i> sp., <i>Ranunculus</i> sp., Moss		
Weidingen,	Em	<i>Agr. stolonifera</i> , <i>Mentha aquatica</i> <i>Ph. arundinacea</i>		d
upstr. STW	WS	<i>Callitriche</i> sp., Benthic algae		
Weidingen,	Em	<i>Agr. stolonifera</i> , <i>Iris pseudacorus</i> <i>Ph. arundinacea</i>		e
dstr. STW	WS	Benthic algae, sewage fungus		
Merkholtz	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i>		e
	WS	Moss, Blanket weed		
Kautenbach	Em	<i>Agr. stolonifera</i> , <i>Ph. arundinacea</i> <i>Polygonum hydropiper</i> agg.		e
	WS	short Blanket weed		

The uppermost site recorded has deteriorated since 1980 (it receives pollution from Belgium). The next group of sites show a probable improvement and so do those in and near Wiltz. The pollution in relation to macrophytes has therefore improved, both here and at the lowest recorded site -Kautenbach. In the Kautenbach site the change is less in the species present than in their habit; in 1980 the species were in poor condition, in 1985 they were satisfactory. (In their habitat however the change might be temporary, due to weather).

The general quality of the river is moderate and the influence of pollution from Niederwampach, Schleif, and Wiltz sewage works is demonstrated in the vegetation.



12. Tributary to river Sure at Echternach (Lauterbornerbach)

This stream was included in the survey because of complaints of macrophyte death in a reservoir getting its water from this tributary. Unfortunately, due to shade, swift flow or extreme smallness of the watercourses, indexing was not possible on the stream.

However, the complaint was that the vegetation grew well in an ornamental lake in its first few years of existence, and then died. The query was whether this could be due to herbicide entering in the inflow tributary.

This pattern does in fact occur after major disturbance, particularly in still or slow-flowing waters. It would be necessary to know the species concerned and more about the habitat, to determine whether this is the cause in that particular lake. The very small watercourse leading to the lake is species rich (indicating no scour and no gross pollution). More importantly for this survey the small *Glyceria* sp was over-lush. This feature is characteristic of mild organic pollution or of high nutrients. It is not characteristic of herbicide damage.

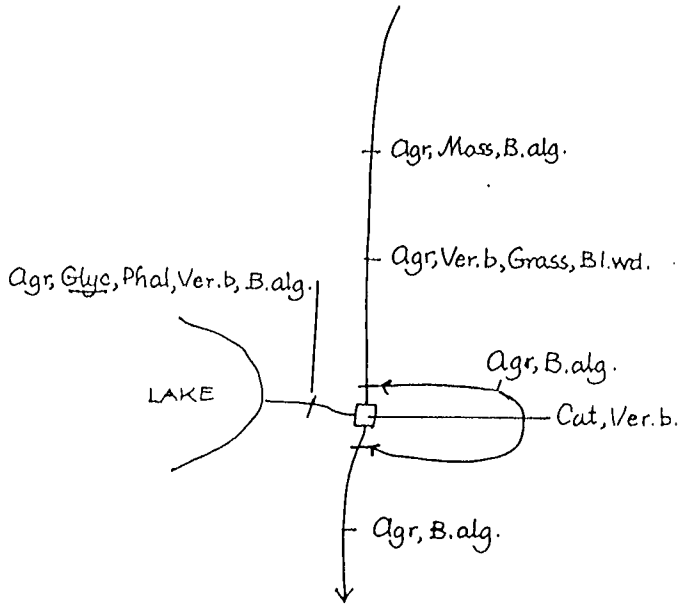
The evidence is inadequate, but on what is available, herbicide damage from the inflow cannot be proven and is unlikely, though it cannot be excluded as a minor damage factor.

12. Tributary of ornamental lake by Echternach

SITE		SPECIES	COVER	DAMAGE RATING
Upstr. Mills	Em	<i>Agr. stolonifera</i>		f
	WS	Moss, Benthic algae		
Dstr. Mills	Em	<i>Agr. stolonifera</i> , <i>Veronica beccabunga</i> , Grass		e
	WS	Blanket weed		
By lake	Em	<i>Agr. stolonifera</i>		(g)
	WS	Benthic algae		
Where lake trib. enters	Em	<i>Cat. aquatica</i> , <i>Veronica beccabunga</i>		(e)
leading to lake	Em	<i>Agr. stolonifera</i> , small <i>Glyceria</i> sp. A, <i>Ph. arundinacea</i> , <i>Veronica anagallis-aquatica</i> agg., <i>Veronica beccabunga</i>	90%	(a/b)
	WS	Benthic algae		
Dstr. lake areas	Em	<i>Agr. stolonifera</i>		(g)
	WS	Benthic algae		

12. TRIBUTARY TO ECHTERNACH

Diagrammatic



DAMAGE RATINGS AND POLLUTION INDICES

A + or - sign beside an index letter does not indicate a half way stage. D+ means the index is D or better (i.e. D, C, or less probably, B or A). It does not mean the index is intermediate between D and C. Such grades are shown as C/D. U indicates unclassable.

SITE	DAMAGE RATING	INFLUENCING FACTOR OTHER THAN POLLUTION, POLLUTION INDICATORS OTHER THAN SPECIES ASSEMBLAGE	POSSIBLE POLLUTION INDEX
1. River Alzette			
Schifflange	g	<i>Phalaris flaccid</i> . "Toxic line", rubbish	G-
Nr Bergem, trib.	e	Too small for accuracy	(E-U)
Bergem, Mess	e	Too small for accuracy	(E-U)
Nr Bergem, trib	g-	No macrophytes	G-
Nr Bergem (main)	(g-)	"Toxic line", poll. inflow, part shade	G-
Nr Bergem (parallel)	g		G
Nr Bergem, confluence	g	"Toxic line"	G-
Nr Noertzange	g		G
Bettembourg	g	"Toxic line", turbid inflow, part shade	G-
Hesperange	g		G
Itzigersté	g-	2 STW upstr., much vegetation	G-
Luxembourg	g		G
Clausen	e	Part walled	E+
Dommeldange	g-	Factory (toxic, heavy metals). Inflow pattern. Vegetation	G-
Dstr. Walferdange	g-	STW upstr., "toxic line", part shade	G-
Upstr. Lintgen	g-	Much vegetation	G-
Mersch	g-	Much vegetation, part stoned	G?
Dstr. Mersch	g-	"Toxic line", vegetation	G-
Moesdorf	g	<i>Phalaris flaccid</i>	G
Essingen	g-	Much vegetation (part shade), part walled, weir	G?
Cruchten	g-	Part shade, vegetation	G-
Colmar	g	(land sp. yellow), part shade, vegetation	G
Ettelbruck	g	(More Blanket weed), part stoned, walled	G
2. River Attert (Unstable substrate and bed)			
By frontier	f	Pollution from Belgian road and villages, part stoned	F+
Eil	e	Upstr. village, villages close on river, part shade	E+
Redange	f	Especially unstable, part shade	F+
Reichlange	d	Much fish, part shade	D+
Upstr. Useldange	g	Especially unstable, part shade	F+
Useldange	d/e	Concreted etc	U
Boevange	e	<i>Solanum</i> yellow, part shade	E+
Bissen	e	Iron & steel factory upstr., part shade	E+
Upstr. Berg	e	Fact. upstr., part stoned, part shade	E+
Berg	d	Tyre factory upstr., <i>Phalaris flaccid</i> , part shade	D+

3. River Clerve (Plateau upstr., sloping dstr., little maize)

Breidfeld trib.	d	Too small for good assessment	D+
Nr Sassel trib.	c	Too small?	C+
Mauldsmuhle trib.	(f)	Side doubtful for assessment	(F?)
Maulusmuhle main	(e)	Site doubtful for assessment	(E?)
Maulusmuhle Millstr.	e		E
Dstr. Clervaux	g-	No vegetation, part shade	G-
Drauffelt	d	Part walled	D+
Drauffelt trib.	a	Village well upstr., part shade	A
Enscherange	e	Part stoned, walled	E+
Wilwerwiltz	f	Town, part walled	F+
Kautenbach	c	Disturbance, hill, part walled	C+

4. River Esch

Hagen	e	Sewage fungus, <i>Phalaris flaccid</i>	E-
Eschen	g	Part walled, but plants absent from optimal habitat	G
Hobscheid	c	Part shade	C
Septfontaines	d		D
Roodt	c/d	(Eutrophic?), part shade	D+
Bour	e	(Eutrophic?), part shade	E
Marienthal	d	Part walled, altered	(D)
Dstr. Marienthal	f/g	Part shade	F+
Hunnebour	d	Kingfishers died recently, Maize	D
Reckange	e	Part shade	E
Mersch	e	Part walled, part shade	E+

5. River Ernz Blanche (Upstr. lowland, dstr. gorge)

Altlinster	c	Too small for food assessment?	C+
Koedange	d	Part shade, little field drainage	D
Soup	f	Much shade, cattle	F+
Upstr. Larochette	b	Part shade	B
Larochette	d	Part shade	D+
Upstr. Medernach	e	Part wall, part shade (slaughterhouse)	E(+)
Medernach	g	Part shade, village	(G+)
Upstr. Ermsdorf	d	Part shade	D
Ermsdorf	g	Walled, part stoned	(F+)
Neumuhle	d	Part shade	D
Dstr. Neumuhle	g-	Full gorge, shade. Reduced by this	G-
Upstr. Hessemuhle	e	Much shade	E+
Reisdorf	c	Walled, village, part shade	C+

6. River Ernz Noire (Upstr. lowland, dstr. gorge)

Ernster	(b)	No scour, little drainage	(B)
Gonderange	(b)	No scour	(B-)
Junglinster dstr.	e	Part walled, part shade	E+
Blumenthal	g-	Part shade, part unsuitable for vegetation	G
Dstr. Reuland	c	Part shade, good vegetation in optimum habitat only	(C+)
Consdorf trib.	f	Much shade, gorge	U
Consdorf	f	Much shade, gorge	F-U
Mullerthal	e	Part walled, gorge	E
Dstr. Mullerthal	g-	Shade, gorge	U
Vogelsmühle	g	Shade, unstable, gorge	U
Grundhof	e	Part walled, village	E+

7. River Mamer (wooded gorge dstr.)

Garnich	e	Part bank-shaded, narrow, too small	(E+)
Holzern	f	Part shade, semi "toxic line"	F-
Dstr. Mamer	g-	Much shade, semi "toxic line", gross pollution, woody gorge dstr.	H
Upstr. Kopstal	g	Part walled, part shade	G
Kopstal	e	Village	E+
Direndall	g-	Part shade	G-
Upstr. Schoenfels	f	Much shade	F?
Upstr. Schoenfels	e	Part shade, cows	(E+)
Dstr. Schoenfels	e	Much shade	E-
Upstr. Mersch	e	Part shade	E+
Mersch	c		C

8. River Our (Hilly upstr., valley-gorge dstr.

All too hilly, unstable and turbid for good assessment)

Dasburg	e/f	Part stoned	
Untereisenbach	f	unstable	
Vianden, dstr.	f	Stone lines	
Vianden, dstr. STW	f?		
Bettel	d	Part stoned edge, stone lines	
Hoesdorf	e	Part stoned	
Upstr. Wallendorf	d	Stone lines, camping disturbance.	

9. River Sure (Upland upstr., valley-gorge dstr., level variable dstr. of reservoir)

Martelange. upstr.	c	Part walled, village	C+
Martelange dstr.	e	part walled, village	E+
Bigonville	c		C
Pont de Misère	(e)	Reservoir	U
Pont de Misère	(e)	Reservoir	U
footbridge			
Heiderscheidergrund	(c)	camping disturbance, level high, stone lines	C+

(River Sure continued)			
Tadler Moulin	(b)	Level high, too turbid, camping disturbance	(B)
Dirbach	(g?)	Level high, too turbid, doubtful	W
Ingeldorf	e		E
Diekirch	(h)	Ornamental, canoes, not seen properly	(W+)
Gilsdorf dstr.	d		D
Bettendorf	c?	(Above construction), canoes	(C?)
Trib.	g		G
Moestroff	a/b	Part walled, varied habitat	B
Reisdorf	d	Canoes	D(B-F)
	(b-f)		
Wallendorf	c	Canoes	C
Dillingen	b	Stone lines, camping disturbance, canoes	B
Bollendorf	b		B
Weilerbach	f	Most edge vegetation prevented by tree overhang, centre too deep	(E+)
Echternach	b	Ornamental	B
Rosport	d	Semi-reservoir, canoes, camping disturbance	D+
N of Langsur	b	Part stoned, boats etc	B
Wasserbillig	g+	Level high from reservoir, boats etc	U

10. River Syr (Lowland upstr., lowland tribs., woody gorge, dstr.)

Upstr. Syren	f	Too small	U
Upstr. Syren	(e)?	Too small, part walled	(E+)
Syren	f	Part walled, part shade	F+
Dstr. Syren (main)	-		U
Dstr. Syren (Millstr.	b		B
nr Medingen trib.	(g-)		U
nr Medingen trib.	d		D
Dstr. Medingen	e		E
Moutfort	c	Part walled and nil, all spp poor	C-
Oetrange	g	Part shade, dredged several years before	G
Schrassig	g	Part shade, dredged, airport drainage	G
Schrassig airport	g	Walled	G+
trib. upstr.			
Schrassig airport	b	Part walled	B
trib. dstr.			
Ubersyren	c		C
Ubersyren dstr. STW	d		D
Munsbach	c	Edges suitable for more vegetation	C
Roodt	e		E
Olingen	e	Cattle	D+
Betzdorf	c	Cattle, Solanum yellow	C
Hagelsdorf	d		D
Wecker	f		F
Wecker Dstr. STW	e	Part shade (Urtica yellow)	E-
Manternach	d		D
Manternach	e		E
Dstr. confl. Berb. trib.	e	Part shade, gorge, wooded	U
Dstr. confl.	g?	Part shade, gorge, wooded	W
Dstr. confl. Lellig	d	Much shade, gorge, wooded	D
Mertert	e	Part stoned	E

Boudlerbach

Upstr. Boudler	e	Part shade, too small for good assessment	E
nr Boudler	(g)	Part shade, not seen clearly	(G?)
nr Boudler	(g)	Part shade, not seen clearly	(G)
nr Boudler	b	Part shade	B
Biwer	g	Lined (bed and side)	(F+)
Wecker	g	Part walled, part shade	G

Berbourgbach

Berbourg	c	Dstr. <i>Phragmites</i> marsh	C
Dstr. Berbourg	f		F
Dstr. Berbourg	g-		G+
Dstr. Berbourg	g-	Much shade	G+

Lelligerbach

Upstr.	d	Grassland to edge, too small	D+
Dstr.	d		D
Dstr.	g-	Much shade	F+
Dstr. trib.	g	Much shade	F+
Herborn	g	Part shade	G+
Upstr. Lellig	(d)	Part shade	D
Lellig	(g)	Cattle?, part shade	U
Syr Confl.	g-	Shade, gorge, wooded	U

11. River Wiltz (Hilly except upstr.)

Near Frontier	b		B
Upstr. Niederwampach	b		B
Niederwampach, Upstr. confl.	c		(C+)
Niederwampach, trib.	e		(E+)
Niederwampach, dstr. confl.	d		(D)
Upstr. Schleif	e		(E)
Schleif	g-		(G?)
Winseler dstr.	c	Stoned	fair
Mill	d		fair
Wiltz	b	Walled	(B)
Weidingen	d	Part shade	D
Weidingen dstr. STW	e	Much shade	E
Merkholtz	e	Part shade	(E+)
Kautenbach	e	Too shallow for <i>Ranunculus</i> , part walled	(E+)

12. Tributary to Echternach. Not suitable for indexing.

Upstr. mills	f	Shady, swift	
Dstr. mills	e	Part stoned, shade, swift	
Near lake	(g)	Part walled, rest shaded	
'pond' in last	(e)	Walled	
to lake	(a-)	No scour, <i>Glyceria</i> sp. lush	
Dstr. lake	(g)	Walled, shade, swift	

IV. DISCUSSION AND INTERPRETATION

This survey was commissioned because concern had been expressed as to whether herbicides were entering streams and harming the vegetation there, so leading to damage to the fisheries. The growing of maize has much increased in recent years and it was reported that atrazine is applied more liberally to maize than it and other herbicides are to other crops. In addition, a decline in *Ranunculus* - that species much favoured by anglers - had been reported in the lower Sure, which worried the anglers.

It is known that land herbicides spread from their proper site of application by drift during spraying and by wash-out afterwards. It is also known that herbicides and their degradation products can have serious and long-term effects on "wild" vegetation near crops. These effects include the alteration of the chemical environment and the inhibition of seed germination as well as the death of plants present at the time of spraying. On the other side of the picture biocides may be necessary for the production of adequate food. Also, in areas conserved for wildlife, properly applied herbicides can be the management tool of first choice to maintain high-quality flora and fauna.

Some rivers in the maize belt of America were so poisoned by herbicides that no plants could grow in them. In Britain a factory was unknowingly discharging such a small concentration of a biocide that new equipment had to be developed to detect it. This effluent however was decreasing macrophyte diversity for some tens of kilometers downstream and even after further dilution it was killing tomato crops where the river water was used for irrigation.

Therefore it is wise for doubt to be felt and expressed about the excessive or improper use of herbicides. This survey, however, found no firm evidence of any herbicide damage in the investigated rivers (see in particular the Sure, Syr and Lauterbornerbach). The pollution from organic (and industrial) wastes (comprising effluents from sewage treatment works, from less-treated domestic sewage, from farms and from isolated factories etc) is sufficient to account for the macrophyte damage observed. It is certainly possible that more detailed investigation would detect pollution from other sources, including herbicides and fertilisers. But any such damage is at this level of investigation masked and overridden by the much greater damage done by organic wastes.

No main river site on the eleven investigated rivers was rated as completely clean for vegetation in 1985. Clean tributaries have been recorded (one in 1985, others in earlier surveys). In general, however, pollution from settlements etc make the river quality vary from moderate to very bad. In general terms the order of the rivers from worst to best for their plant communities is:

Alzette; Mamer; Syr; Attert; Clerve and Eisch;
Ernz Blanche and Ernz Noire and Wiltz; Sure.

This places the worst rivers in densely populated lowland farming (and industrial) regions. The River Maps show that within rivers, sites down-

stream of sewage treatment works are among the worst on each river and the other badly polluted stations have equivalent sources of pollution, because macrophytes are sensitive to pollution from organic wastes.

Is this amount of damage to vegetation harmful to any interests or factors other than the vegetation? There are two reasons why anglers want a certain amount of weed and particularly wish for *Ranunculus*. Vegetation provides cover and substrate for invertebrates and food for some of these. Therefore a good invertebrate population may depend on a good plant community. Many fish feed on invertebrates, some on plants. Vegetation also provides cover and shelter for the fish, including protection for young fish and sometimes for spawning grounds. In very slow flows the input of organic matter from the side may suffice to support an adequate invertebrate and coarse fish population without plants in the streams themselves. In hill streams the varied habitat formed by boulders, riffles and pools can substitute for vegetation except as a food source. In some circumstances macrophytes oxygenate a river. Often the micro-organism growing on macrophytes purify the water, much aiding downstream recovery from pollution.

Ranunculus is aesthetically pleasing and in suitable quantities provides a loose cover, aiding easy fishing and the good protection of fish. However, too much *Ranunculus* can prove even more annoying to anglers than too little! Some tests have shown it is not the *Ranunculus* per se which attracts a good invertebrate and hence fish population, it is instead the type of flow and any other trailing species in the same flow bears the same invertebrate population. In the Sure therefore it is important to determine why the anglers object to the loss of this species in the lower Sure. If it is for a loss in invertebrates, in fact the remaining vegetation is adequate in most of the sites recorded. If it is for the loss of cover for the fish, other species may eventually substitute. If it is for the loss of a pleasing bright green plant, other species are unlikely to substitute. It is likely that the general habitat is now unsuitable for much re-invasion.

Some of the other rivers have too little vegetation for optimum invertebrates and fisheries in lowland streams. However, the deficiency is seldom serious over long sections.

For aesthetic reasons, a higher cover and a more diverse flora is preferable. The present vegetation of these rivers often appears dull. There may be too few species and too little cover to enhance the value of the riverscape. A pleasing riverscape has as its focus a river with a varied look. This variety can come either from boulders, riffles, pools, falls etc in hilly stretches or, in smaller rivers, from patterned vegetation in lowland parts. Patterned vegetation can be made up in different ways. It may include tall reed-like plants plus short bushy plants at the edges and long trailing and short bushy plants (or other contrasted habits) within the water. Such vegetation should cover at least 20% of the bed and be composed of different shades of green, as well as of different shapes of plants. In this respect the Luxembourg rivers suffer from pollution damage. It is of course the least important reason why expensive alterations should be made in river management!

Europe-wide there is a tendency for the production of sewage wastes in rivers to increase. Population is increasing, the proportion of that population with drainage to a stream or sewage treatment works is increasing, the amount of water used per household is increasing and so is the number of different household chemicals and types of factory effluents. The production of new and better treatment works is, as ever, often not keeping pace with the new requirements. Comparing the surveys done in-1977-80 with the one done in 1985, most rivers show no effective change, a few show slight improvement and one, slight deterioration. It would have been nice to have recorded substantial improvements. However, there is one pleasing conclusion from the comparison. Maize-growing has spread rapidly since the earlier surveys. It can therefore be proved that in the rivers surveyed earlier there has been no substantial loss in vegetation attributable to the spread of the maize. Atrazine has, as yet, had no overall deleterious effect. Careful observation should be maintained in future years. It should be remembered that, as with nitrates, once an effect shows in the rivers, the position may be so serious that a cure would be very difficult, expensive and lengthy. Preventive measures should be taken once any firm evidence of damage is found.

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