Bull. Environm. Contam. Toxicol. 26, 228-232 (1981)

Influence of Chromium (VI) upon Stream Ephemeroptera in the Pre-Alps

Mario Cotta Ramusino[1], Guido Pacchetti[1], and Alberto Lucchese[2]

[1]Istituto di Zoologia, Via Celoria, 10, 20133 Milano, Italy; [2]Via Sulmona, 23, 20139 Milano, Italy

The aim of this work is to study variations in Ephemeroptera larvae populations resulting from pollution in a typical pre-alpine watercourse.

The Grua stream - 13 km long, average slope 4% - springs from Mount Zuccaro 850 m above sea level and flows into the Agogna nearby Borgomanero, 308 m above the sea.

4 km downstream from its source it receives tributaries flowing through industrial areas where metals are galvanized. This is to be considered the sole polluting factor.

MATERIALS AND METHODS

Sampling

5 sampling sites were chosen along the stream. Water is polluted between site 2 and 3. Sampling began on the 19th of February and continued through January 1978.

Benthos was sampled with a Surber net (14 meshes per cm, side length 50 cm) so as to cover a sampling surface area of 1 sqm. Samples were immediately fixed in 10% neutral formalin.

Variables

The following variables were considered: water temperature, dissolved O_2, % of O_2 saturation, pH, conductivity, hardness, alkalinity, C.O.D. and dissolved Cr^{6+}. Tests were performed according to the method suggested in "Metodi analitici per le acque" (I.R.S.A. 1972).

Statistical analysis

Statistical data were obtained by standard SPSS programs run on a UNIVAC 1100/81 computer (NIE et al. 1979). Data have been normalized by a $\log_{10}$ (10 + x) transformation. Discriminant analysis was performed according to the stepwise procedure which maximizes Rao's V.

RESULTS

Chemical and Physical Variables

Figure 1 shows the annual geometric means and the corresponding 95% confidence limits for each chemical and physical variable and

0007-4861/81/0026-0228 $01.00

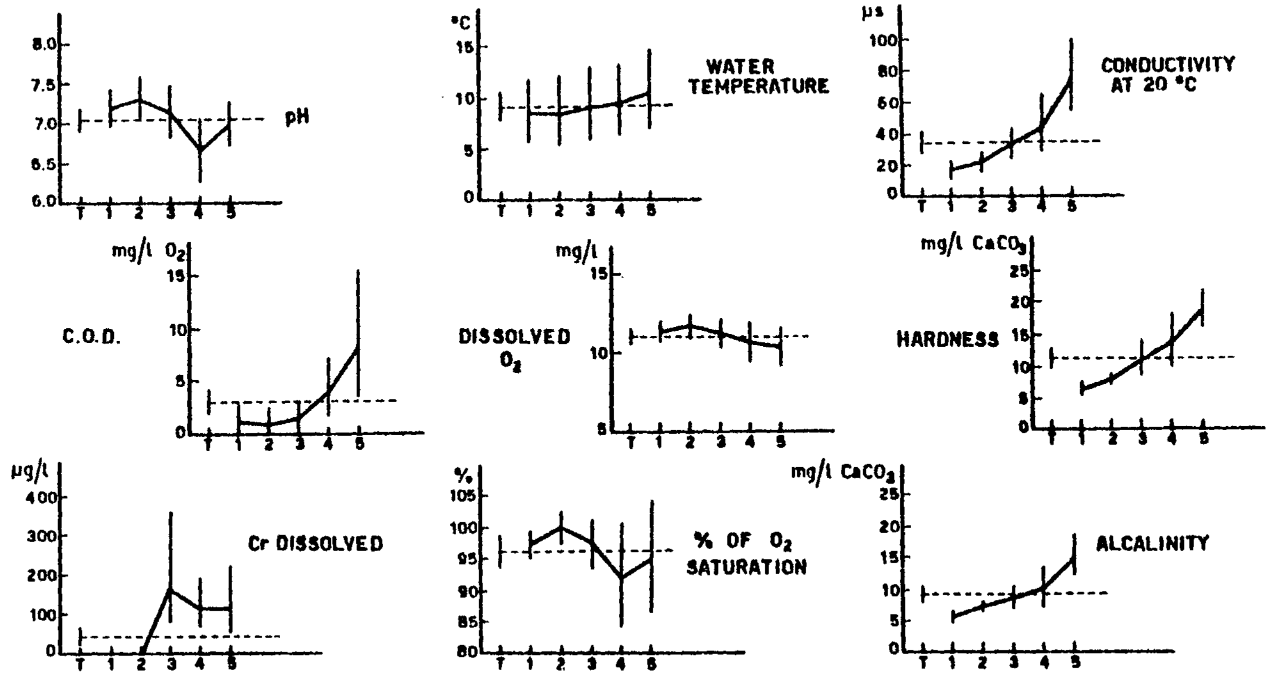

FIGURE 1: Annual geometric means and 95% confidence limits for each site. 1, 2, 3, 4, 5 = sampling sites T = overall statistical values.

for each individual site. Cr^{6+} concentration values only are not consistent with those of pure waters. Except for some abrupt fall in the annual geometric mean of O_2 saturation and pH on site 4, an upward-downward gradient is found which decreases for dissolved O_2 and increases for the other variables.
Site 2 through 5 appear to be oversaturated with O_2 during several months. Site 3 seems to vary the most as regards Cr^{6+}. Such variation levels decrease in the next two sites possibly due to both mixing and dilution.

The homogeneous gradient for all the variables considred - Cr^{6+} excluded - is further confirmed by stepwise discriminant analysis (TABLE 1,a).
On the basis of the F matrix, centroids appear to be neighbour-pairwise not significant at the 5% level, except for site 4 and 5. However, il Cr^{6+} concentration is included the pattern changes considerably (TABLE 1,b). If this is the case, sampling sites can be further divided into 2 more subsets, the former comprising the upper two sites and the latter comprising the lower three. The homogeneity of the lower three sites becomes evident in the high F ratios as opposed to the two sites located further up.

According to these data we can conclude that different results for the sites considered are obtained as a result of the presence or absence of Cr^{6+} and not as an influence of this ion on the chemical and physical context affecting the normal gradients caused by geographical factors.

TABLE 1: Matrices of pairwise F ratios. The F ratio for each pair of sites tests the significance of the Mahalanobis distance between pairs of group centroids.
Legenda: F = F ratio; S = significance; D.F. = degrees of freedom for numerator and denominator respectively;
- = not significant; + = significant at the P = 1% level.

Variables included	Site	SITE 1		SITE 2		SITE 3		SITE 4		D.F.
		F	S	F	S	F	S	F	S	
(a)	2	2.05	-							
Chemicophysical	3	5.19	+	2.01	-					
without Cr^{6+}	4	7.32	+	5.30	+	1.57	-			6,45
	5	24.53	+	14.11	+	7.98	+	9.21	+	
(b)	2	1.89	-							
Chemicophysical	3	17.15	+	17.01	+					7,44
with Cr^{6+}	4	12.88	+	12.90	+	2.12	-			
	5	27.17	+	20.56	+	7.48	+	8.31	+	
(c)	2	4.65	+							
Ephemeroptera	3	10.78	+	10.17	+					4,47
species only	4	13.25	+	11.91	+	0.20	-			
	5	13.72	+	12.16	+	0.28	-	0.01	-	

Biological results

Annual geometric means and 95% confidence limits are given for biological variables also (Figure 2). It can be seen that the Ephemeroptera community tends to disappear as we proceed further down below the polluting source. Discriminant analysis (TABLE 1 c) confirms the homogeneity of the three lower sites far better than including Cr^{6+} in the discriminant analysis of the chemical and physical data.

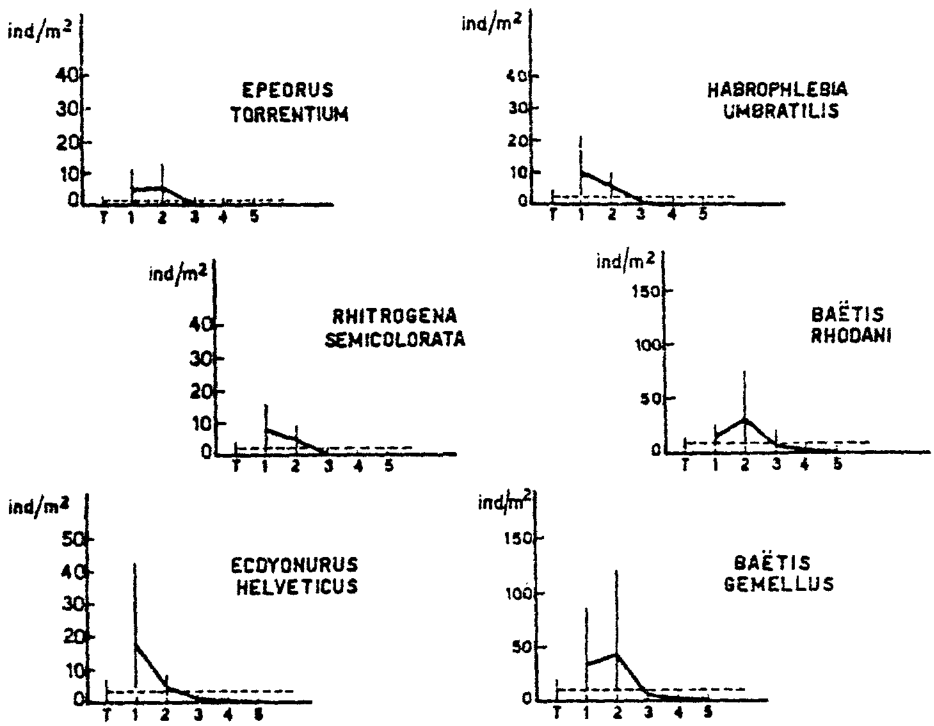

FIGURE 2: Annual geometric means and 95% confidence limits for each site. 1, 2, 3, 4, 5 = sampling sites. T = over-all statistical values.

The upper subset of sites does not seem to be homogeneous possibly due to geographical factors. Species collected were the following:

Epeorus torrentium: particularly copious from October until January, lives in fresh and rapid mountain streams, adhering to bottom pebbles (GRANDI 1960).

Rhithrogena semicolorata: highest density of individuals observed in the wintertime. Habitat similar to that of Epeorus larvae (GRANDI 1960; MACAN 1961).

Ecdyonurus helveticus: common all over Italy, typical of mountain watercourses with bed made of rocks and crushed stones. Highest density in January.

Among Ephemeroptera this is the species most likely to be affected by suspended material (HYNES 1959).

Habrophlebia umbratilis: highest density November until January. Its needs in terms of water quality are unknown.

Baëtis rhodani: highest density in June (596 individuals per sqm on site 2). According to some authors (HYNES 1959; BIELLI et al. 1978) larvae are particularly resistant to pollutants.

Baëtis gemellus: typical of cold and well oxigenated water. (GRANDI 1960).

CONCLUSIONS

On the basis of the results obtained it can be concluded that Ephemeroptera larvae are good indicators of the deep crisis affecting benthos in the Grua stream. Such crisis is to be attributed to persistingly high concentrations of dissolved Cr^{6+} as evidenced by statistical analysis.
Other factors such as chemical and physical changes do not seem to be involved.

It was also seen that E. torrentium and Rhitrogena semicolorata are hardly found on site 3, whereas the remaining four species are found on Cr^{6+} polluted sites. This could be explained as an effect of currents carrying the animals downstream (WATERS 1961, 1962; BIELLI et al. 1978). The two Baëtis species which can reach very high densities on polluted sites turned out to be the most resistant.

REFERENCES

BIELLI, E., M. COTTA RAMUSINO and F. SEGRADA: Rend. Sc. Ist. Lomb. B 112, 17 (1978).

GRANDI, M.: Fauna d'Italia 3, Ed. Calderini, Bologna (1960).

HYNES, H.B.B.: Proc. Limn. Soc. London 170, 165 (1959).

I.R.S.A.: Metodi Analitici per le Acque 1 and 2, Ed. La Pergamena, Roma (1972).

MACAN, T.T.: Freshwater Biol. Ass. Sci. Pub. 20 (1961).

NIE, N.H., C.H. HULL, J.G. JENKINS, K. STEINBRENNER and D.H. BENT: Statistical Package for the Social Sciences, Mc Graw-Hill (1975).

WATERS, F.T.: Ecology 42, 532 (1961).

WATERS, F.T.: Trans. Am. Fish. Soc. 91, 243 (1962).