Case study of the colonisation of artificial substrates by benthic macroinvertebrates in the lagoons of a wastewater treatment plant and in the watercourse receiving the affluent.

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ABSTRACT

This work is part of a study on the depuration efficiency of a wastewater biological treatment plant (WTP) and on the impact of the plant on the watercourse receiving the effluent through the analysis of the benthic macroinvertebrate community.
The objective of the present work is to give estimates of the colonisation time of artificial substrates by macroinvertebrates. The substrates were broken bricks held in plastic net bags. These were placed in the four lagoons of a WTP and in three points along the watercourse receiving the effluent.
Samples were collected biweekly, during three months, and analysed using the benthic macroinvertebrate community method. The "best colonisation time" (BCT) was determined by analysis of the time variation of variables such as number of organisms, belgium biotic index, Shannon-Weaver diversity index and the Pielou equitability index. BCT corresponds to the moment when more than majority of values of these variables are maximal, BCT was usually thirty days.
After this period a stabilisation or even decrease of these values was apparent.

Keywords: artificial substrates, colonisation time, benthic macroinvertebrates, water quality

RESUMEN

Este trabajo es parte de un estudio más amplio ***de*** *evaluacidn de la eficiencia de una depuradora biológica y del impacto de su efluente en el rio receptor:*
En este estudio se hace la determinación del mejor tiempo de colonizacidn de substratos artificiales, hechos con trozos de ladrillos dentro de bolsas de red deplastico, en las lagunas de la depurudora y en el rio receptor del ejluente.
Los substratos fueran colocados en las cuatro lagunas de la depuradora y en tres puntos de muestreo en el rio y recogidos cada quince dias durante tres meses, para el estudio de sus macroinvertebrados.
Se ha estudiado la variación de algunos factores relativos a la comunidad de macro invertebrados (número de organismos, indice bidtico belga, indice de diversidad de Shannon- Weavere indice de equitabilidad de Pielou) y se ha determinado el tiempo dptimo de colonizacidn de los substratos en los dos sistemas estudiados, que era de treinta dias. La permanencia en los substratos más de treinta dias puede incluso provocar una disminucion de las variables estudiadus.

Palabras clave: sustratos artificiales, tiempo de colonizacidn, macroinvertebrados bentdnicos, calidad del agua

INTRODUCTION

This work is part of a study of the depuration efficiency of a biological wastewater treatment plant (WTP) using the analysis of benthic macrominvertebrate community (Jesus, 1996).

The aim of this paper is to give estimates of the best colonisation time by macroinvertebrates on artificial substrates in polluted waters.

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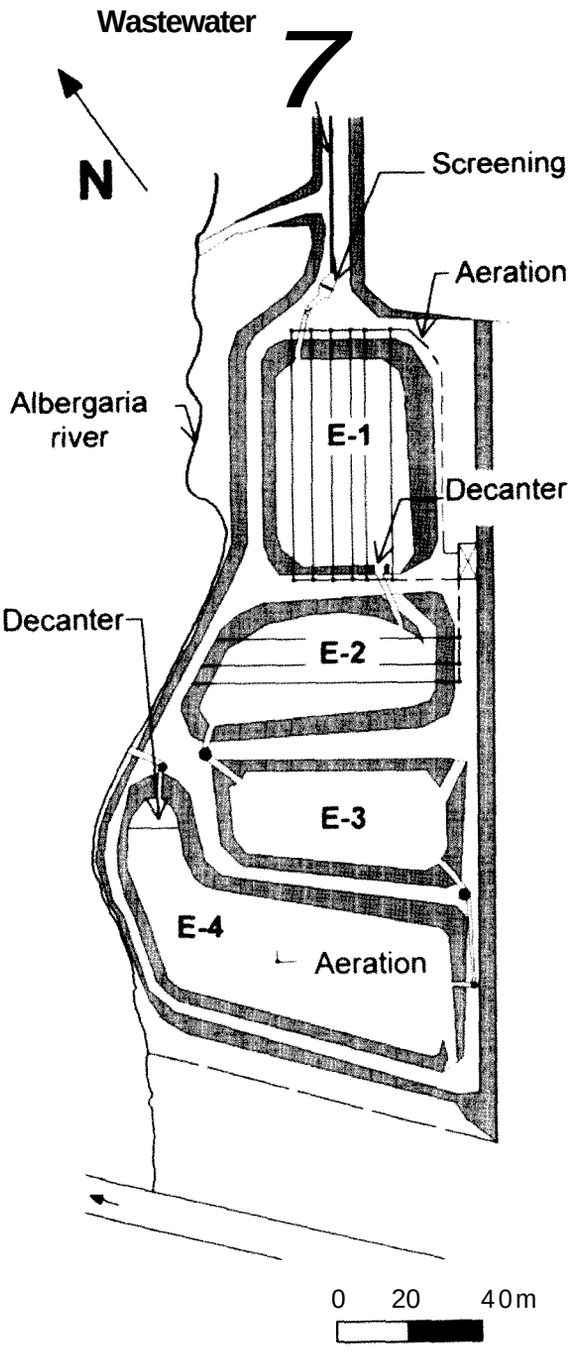

Figure 1. Map of the wastewater treatment plant of Albergaria-a-Velha. *Mapa de la depuradora de aguas residuales* ***de*** *Albergaria-a-Velha*

Artificial substrates try to recreate the same conditions of the natural macroinvertebrate habitats.

The main advantages of their use are their ability to be used in every kind of aquatic systems, standardisation sampling efforts reducing the variability associated with the hand-net method (Hellawell, 1986).

The major disadvantage is that they are prone to vandalism while in the river (Lamotte & Bourliere, 1971; De Pauw *et al.,* 1986; Campaioli *et al.,* 1994).

MATERIAL AND METHODS

Six pairs of substrates were placed in the four lagoons of the WTP from October 1995 to January 1996 (Fig. 1). The artificial substrates were made of brick pieces approximately 5 cm long held in plastic net-bags (mesh size about 1 cm) with 4000 cm^3 of volume, (Fontoura, 1985; Campaioli *et al.,* 1994). Substrates were placed in the first and second aerated lagoons (E-1 and E-2), in the sedimentation lagoon (E-3) and in the maturation lagoon (E-4). Also, substrates were situated in three points across the Albergaria River (Fig.2), one upstream the WTP (E-5), and two downstream of the point of effluent discharge (E-6 and E-7). A pair of brick bags was collected every fortnight, during the three months of study.

The substrates collected were treated by the technique described in Jesus (1996). The macroinvertebrates were identified to the taxonomic categories suggested for the calculus of the Belgian Biotic Index (Fontoura, 1985; Jesus, 1996), with help of some identification guides, (Tachet *et al.,* 1980; Mouthon, 1982; Lafont, 1983; Faessel, 1985; Fontoura, 1985; Campaioli *et al.,* 1994; Fitter & Manuel, 1994).

Time changes of the benthic macroinvertebrate community were examined using log total abundance, Shannon-Weaver diversity index, Pielou equitability index and Belgian Biotic Index (Tuffery & Verneaux, 1968; Johnson & Brinkhurst, 1971; Ludwig & Reynolds, 1988; Washington, 1984). The "best colonization time"

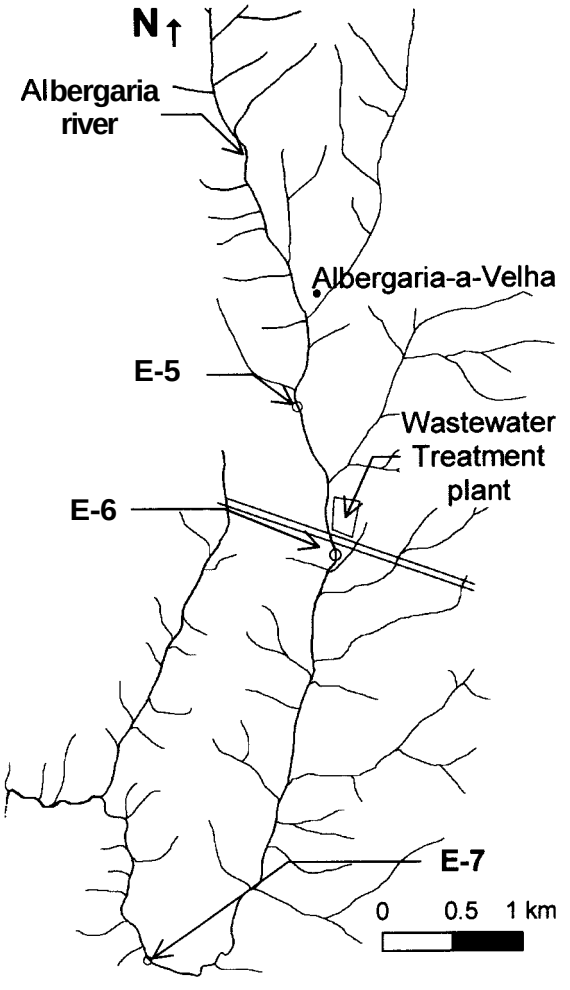

Figure 2. The Albergaria river drainage basin. *Cuencu del río Alberguriu.*

was defined as the time, when most analysed variables reached their maxima (Rosenberg & Resh, 1982).

RESULTS & DISCUSSION

Organic matter as measured by BOD in the WTP decreased by the action of microbial activity as it passed through the four lagoons (E-1 to E-4) (Table 1) (Jesus, 1996). However, higher diversity and equitability were found in lagoon E1 (Fig.3), but the of organisms collected was maximal in lagoon E4, though (Jesus, 1996). Because the macroinvertebrate community was poor in all lagoons, the balance between the number of individuals and diversity (i.e. number of taxa) in lagoons complicates interpretation of data. Nevertheless, the values of the Belgian Biotic Index reflect an increase in water quality as water circulates through the series of lagoons (Statzner *et al.*, 1994).

		COD (mg O_2/l)	BOD (mg O_2/l)	TSS (mg/l)
October 1995	**E-1**	737	250	224
	E-2	251	117	51
	E-3	112	78	41
	E-4	179	125	31
December 1995	**E-1**	404	170	103
	E-2	106	47	41
	E-3	103	45	27
	E-4	67	30	20

Also, values measured in each lagoon (Table 1) decreased with air temperature and flow increases. Thus, the organic charge arriving to the system and promoted by rainfall was diluted (Jesus, 1996).

Water quality improved during the three months of the study. Highest richness, diversity and biological water quality were obtained about 30-45 days after sampling had begun (Fig.3). After this 30-45 day period values of studied variables generally decreased.

Occasional higher values were recorded after 75 and 90 days of colonisation. Improvement of water quality, may have promoted recolonization of the system by more pollution-sensitive organisms, mainly in the first lagoon (Statzner *et al.*, 1994; Jesus, 1996).

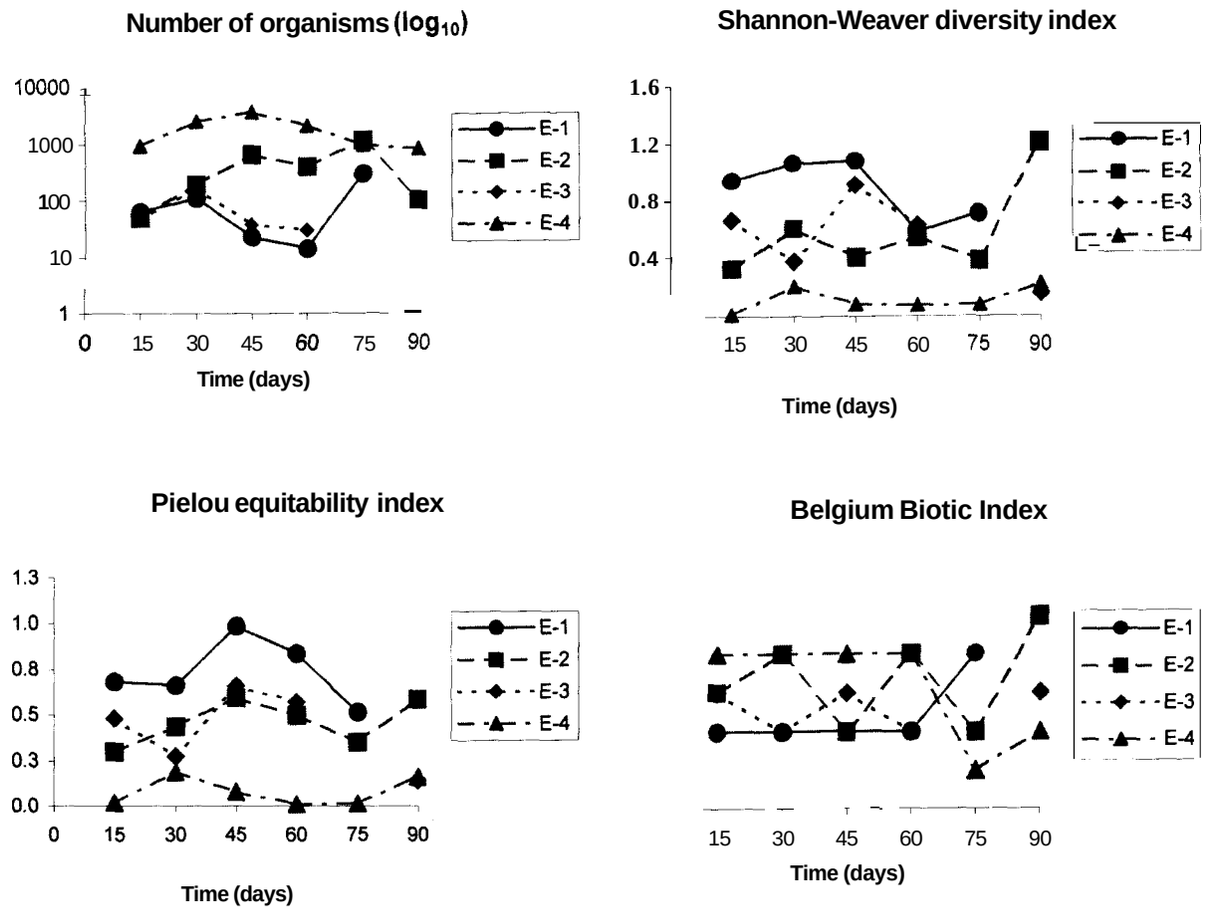

Figure 3. Variation of factors related to the macroinvertebrate community of a Wastewater Treatment Plant. *Variación de los factores relacionados con la comunidad de macroinvertebrados de la depuradora de aguas residuales.*

In Albergaria River physico-chemical water quality registered a decrease between the first (i.e. E-5) and the second (i.e. E-6) sampling site due to the discharge of wastewater from the WTP. Discharge promoted an increase in organic matter and the decrease in oxygen levels in the water (Table 2). This affected the structure and dynamics of the macroinvertebrate community, increasing the total number of organisms, though at the expense of a decrease in diversity of taxa, as the more sensitive organisms died out (Fig. 4) (Statzner *et al.*, 1994). About 3 Km downstream, water quality and the macroinvertebrate community recover to a state similar to that upstream of discharge (Jesus, 1996). (1) Through the analysis of the figure 4 the same conclusions obtained with the WTP were achieved. The maximal values of every variable were obtained about the 30th on 45th days. After this time there were a decrease of all variables.

This can be explained by the occurrence of unsuitable conditions to the survival of the macroinvertebrates on the artificial substrates, such as clogging. Weather, probably influenced community composition and habitat conditions, for instance, dilution of the pollutant charge by rainfall (Rosenberg & Resh, 1982; De Pauw *et al.*, 1986).

Table 2. Values of some physico-chemical variables measured in Albergaria River (2). W.T. - water temperature; Cond. - conductivity; BOD5 biochemical oxygen demand (5 days). (2)data obtained from Jesus (1996); all variables were measured following APHA (1994). *Valores de algunas variables físicas y químicas medidas en el río Albergaria (2). W.T. -temperatura del agua; Cond. - Conductividad; BOD5 - Demanda bioquímica de oxígeno (5 días). (2)datos obtenidos de Jesus (1996); todas las variables fueros medidas según APHA (1994).*

		W.T. (°C)	pH	Cond. (µS/cm)	NO_2^--N (mg/l)	NO_3^--N (mg/l)	NH_4^+-N (mg/l)	PO_4^{3-}P (mg/l)	O_2 (mg/l)	BOD_5 (mgO_2/l)
	E-5	18.0	6.7	170	0.140	0.714	0.257	0.072	6.0	3.4
02-11-1995	E-6	19.0	7.2	370	0.259	0.663	1.391	2.040	6.2	5.2
	E-7	16.0	6.7	300	0.629	0.309	1.221	1.440	6.1	5.0
	E-5	14.5	6.7	215	0.037	1.006	0.123	0.026	8.4	2.1
16-11-1995	E-6	16.0	7.0	305	0.139	0.906	1.743	1.342	7.1	5.7
	E-7	16.0	6.8	250	0.212	0.714	1.423	0.863	8.1	5.7
	E-5	13.0	6.7	175	0.105	0.761	0.070	0.009	9.4	1.4
04-12-1995	E-6	13.0	7.1	255	0.187	0.716	1.475	0.784	8.2	5.9
	E-7	12.0	6.9	200	0.356	0.551	0.536	0.488	8.1	5.7
	E-5	10.0	6.8	150	0.135	0.742	0.092	0.021	9.2	1.3
14-12-1995	E-6	9.5	7.2	240	0.177	0.679	1.850	0.860	8.6	5.4
	E-7	9.0	7.0	200	0.139	0.836	1.015	0.526	8.1	5.6
	E-5	13.5	7.0	160	0.008	0.850	0.038	0.023	9.7	2.2
28-12-1995	E-6	13.0	7.0	170	0.026	0.878	0.414	0.132	9.5	5.3
	E-7	12.5	6.9	150	0.020	0.924	0.178	0.072	9.3	2.9
	E-5	13.0	7.0	120	0.006	0.997	0.053	0.016	9.6	2.0
17-01-1996	E-6	13.5	6.9	150	0.050	0.893	0.346	0.154	9.4	4.2
	E-7	12.5	6.9	130	0.037	0.881	0.205	0.093	9.9	1.7

CONCLUSIONS

Colonisation time needed for a substantial representation of the benthic macroinvertebrate community was about 30 days.

After this time, there was no increase in the number of individuals and of diversity values and there was a stabilisation of water-quality index values. This was due to the community reaching a stable state and to adaptation to the new habitat.

Substrates remaining more than 30 days showed a decrease in the number of individuals, diversity and equitability. This was due to clogging of substrates. Weather conditions could severely alter community structure, too.

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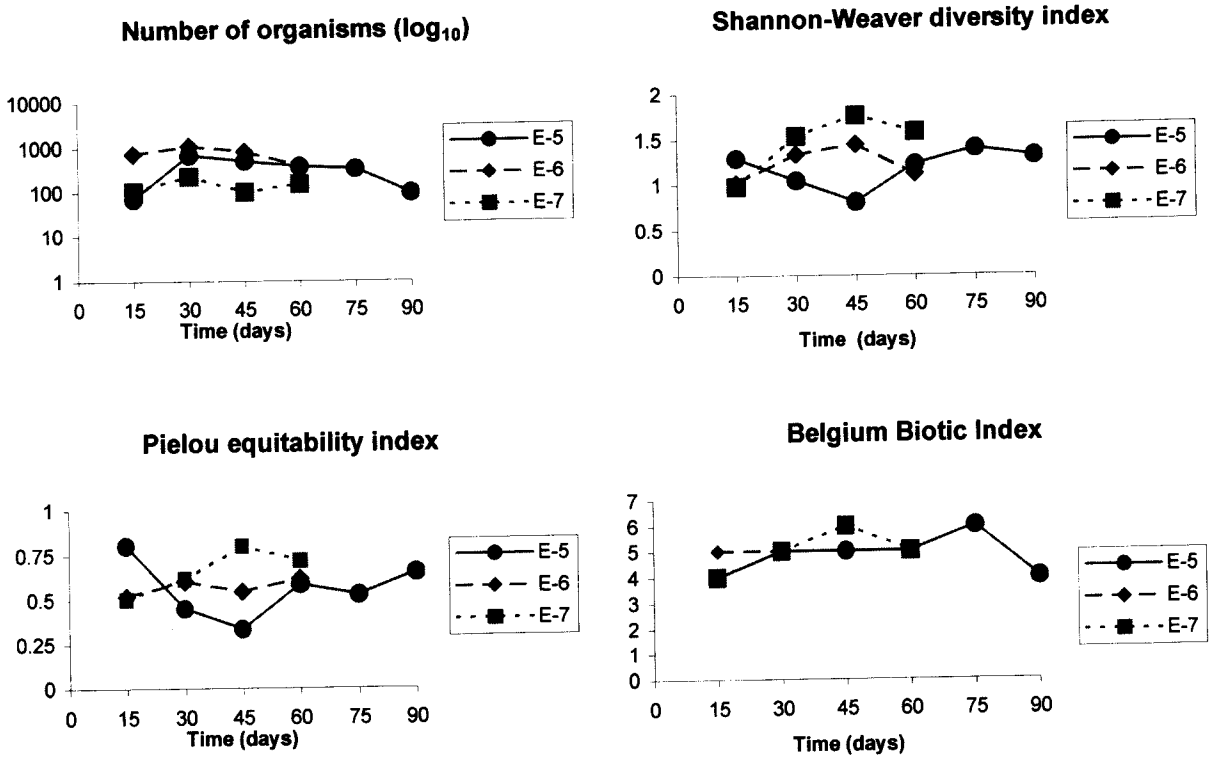

Figure 4. Variation of factors related to the macroinvertebrate community of the Albergaria River . *Factores de variación relacionados con la comunidad de macroinvertebrados del río Albergaria.*

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