



HAL
open science

Association of waste stabilisation ponds and intermittent sand filters: the pilot results and the demonstration plant of Aurignac

Catherine Boutin, A. Lienard, N. Bilotte, J.P. Naberac

► **To cite this version:**

Catherine Boutin, A. Lienard, N. Bilotte, J.P. Naberac. Association of waste stabilisation ponds and intermittent sand filters: the pilot results and the demonstration plant of Aurignac. 8ème conférence internationale on "Wetlands systems for water pollution control", Sep 2002, Arusha, France. 6 p. hal-00508242

HAL Id: hal-00508242

<https://hal.science/hal-00508242>

Submitted on 2 Aug 2010

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**ASSOCIATION OF WASTE STABILISATION PONDS AND
INTERMITTENT SAND FILTERS :
THE PILOT RESULTS AND
THE DEMONSTRATION PLANT OF AURIGNAC**

Catherine BOUTIN, Alain LIÉNARD Cemagref, Research unit: Water quality and pollution prevention, 3bis, quai Chauveau CP 220, F 69336 Lyon Cedex 09.
catherine.boutin@cemagref.fr

Nathalie BILOTTE, Syndicat des eaux Barousse-Comminges-Save, F 31806 Saint Gaudens.

Jean-Pierre NABERAC, Bureau d'études DUMONS, 77 allée de Brienne, F 31000 Toulouse.

ABSTRACT

Many small French communities have been equipped with Waste Stabilisation Ponds (WSP). Their effluent quality is relatively good for N and P but this treatment system is known to have a poor efficiency with regards to organic matter.

Pilot trials show that it is possible to decrease 50% of the outlet SS and to obtain an additional nitrification thanks to one additional filtration on a 25 cm sand height.

The follow-up of a self-priming siphon has shown its capacity to function with only one centimetre height of tidal range, while discharging more than $70 \text{ m}^3 \cdot \text{h}^{-1}$

The owner of Aurignac has accepted to build a demonstration WSP plant, followed by Intermittent Sand Filters (ISF), to treat the wastewater of about 300 PE. He has submitted in November 2001 this project to the EEC in the LIFE-environment program. The primary sludge which accumulates at the inlet of the 1st pond will be spread each day on four Sludge Dewatering Reed Bed Filters (SDRBF). The beginning of the plant's construction is planned during autumn 2002.

This paper gives the results of pilot trials and of the siphon functioning. It describes the demonstration plant, explains our objectives and presents the planned specific monitoring program.

KEYWORDS

demonstration plant, domestic wastewater, intermittent sand filters, pilots, rain water, sludge dewatering reed beds filters, waste stabilisation ponds, wastewater treatment plant.

INTRODUCTION

Their simple investment and operation criteria have led WSP to a strong development in French rural communities. France counts 2 500 WSP mostly constituted by 2 facultative and 1 maturation ponds in series [1]. The EEC regulation agrees that SS concentration reaches $150 \text{ mg} \cdot \text{L}^{-1}$ even for WSP receiving more than $120 \text{ kgBOD}_5 \cdot \text{d}^{-1}$. For smaller communities however, the effluent quality is not always sufficient (see Table 1) according to the limits set by the French regulations.

In case of fragile receiving body for which a higher quality level is now required, the ISF treatment can complement the WSP. The aim is to be able, in the future, to propose to the rural districts, using a combined sewerage system, a treatment process combining WSP hydraulic capacities and ISF residual organic matter elimination and nitrification performances.

Table 1 : Average quality level of the French WSP effluent in mg.L⁻¹ [1].

		COD	COD _f *	SS	N-NK	N-NH ₄ ⁺	TP
All sewerage equipments	Average	162	99	60	22	14	8.5
	<i>std dev.</i>	109	6	5	17	15	8
Separative sewerage networks	Average	198	123	69	25	17	10
	<i>std dev.</i>	109	6	5	17	15	8
Other sewerage equipments	Average	141	85	54	19	12	7.5
	<i>std dev.</i>	69	37	41	11	9	6

COD_f = Filtered COD

ISF treatment plant principle is based on treatment mechanisms by attached-growth cultures on fine media, combined with an alternate feeding of several drained sand filters. This feeding system ensures aerobic conditions and an optimised control of surface clogging [2]. Some trials on an ISF column fed by water coming from the second pond have been performed in Certines (dept. Ain). The aim of these trials was to ensure that a sand commonly used for ISF [3] can allow a SS physical retention downstream a WSP mainly composed of algae in order to reach the request level. The pilot trials also allowed to define the first dimensioning bases of the ISF combined to a WSP treatment.

Besides, to perform batch-feedings without electric power, it is necessary to use a self-priming siphon. Its installation directly into a second pond of WSP needs very low tidal ranges (about 1 cm). In these severe conditions, it is necessary to confirm the working reliability of such a siphon in real operation. The Joudes (department of Saône et Loire) treatment plant has been subject to such a survey.

Because of the promising results and in order to confirm the pilots trials conclusions in full scale, a demonstration plant project has been submitted to the LIFE-environment program (European financing) in 2001 for Aurignac (dept. Haute-Garonne). This project, still in the running in June 2002, will be definitely decided in October 2002.

This paper gives the conclusions of both trials, a detailed description of the Aurignac project and the follow-up method planned for 2 full years.

METHODS AND EXPERIMENTAL PROCEDURES

ISF CERTINES pilot

The pilot is a 50 cm diameter PVC cylinder. The useful sand height has deliberately been reduced to the minimum (27 cm). As many WSP do not have electricity, it is better to test the limit conditions of material height still allowing an ISF gravitary feeding but with a noticeable improvement of the effluent quality. The trials having been performed in 1994, the sand quality ($d_{10}=0,19$ mm, $d_{60}=0,37$ mm, CU=2) was corresponding to the specifications known at this period [4]. Today, this sand would be considered as too fine ($d_{10}<0,25$ mm). The draining layer lies on a perforated PVC plate, with a limited height of 7 cm and is composed of a succession of layers with a granulometry decreasing from bottom to top to limit the sand migration.

During summer 1994 (from 06-29-1994 to 09-15-1994), the pilot, installed downstream the Certines WSP second pond, has been fed by 14 batches on a 3.5 days period followed by the same rest period. During the trials, the hydraulic load of the operating filter has intentionally been increased each month by $0,2 \text{ m}^3 \cdot \text{m}^{-2} \cdot \text{d}^{-1}$. With a starting point at $0,6 \text{ m}^3 \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ on June 29, the operating filter was fed in September with a water height of $1,2 \text{ m}^3 \cdot \text{m}^{-2} \cdot \text{day}^{-1}$.

Twice a week, at the beginning and at the end of the feeding phase, samples have been produced on which COD, COD_f, SS have systematically been measured. From time to time, additional measurements have been done to determine the nitrogen forms. In addition, thanks to the installation of level indicators of the filter surface, infiltration speed has been continuously measured.

The physico-chemical analyses have been achieved according the standards NF T 90.101, NF T 90.105 et NF T 90.110 respectively for COD, SS and Kjeldahl nitrogen. The COD_f form has been obtained after filtration through a membrane composed of glass fibres without definite porosity.

JOUDES wastewater treatment plant

Joudes WSP, dimensioned for 220 Person Equivalent (PE), is constituted of 2 facultative ponds, the third basin being planted with macrophytes. Because of the maintenance problems linked to the vegetation cutting in this third basin, the site has been restored in 1998. The third basin has been scraped clean and transformed in a facultative pond and 2 ISF have been built downstream. They are fed thanks to a self-priming siphon plunging in an intermediate storage basin of 185 m² as measured. The wastewater treatment plant used to receive a very low organic load versus its capacities, the follow-up of its purifying operation was then not of a great interest. Only the survey of the siphon operation has been done.

The exact volume of a batch, diverted on purpose in a flume has been measured by a bubble flowmeter. In parallel, the operating time of the siphon has been measured with a chronometer. With these two values, the flow of water evacuated has been calculated.

The continuous recording of the water height inside the storage basin has been performed during autumn 98 thanks to a bubble flowmeter (type ISCO 3230) powered by 6 days autonomy batteries. Data have been recorded every minute and retrieved twice a week with a portable computer.

The siphon has been set to function with 3 tidal ranges: 1,4 cm, 2,6 cm and 0,6 cm. It is corresponding to the phases named 1, 2 and 3 hereafter.

Historically, the siphon principle has been described by Professor Celestre in 1963 [5] for surface irrigation and then adapted for water treatment. This siphon has been modified and improved to be used with raw wastewater by SINT (Société d'Ingénierie Nature et Technique). The patent has been granted in 1991.

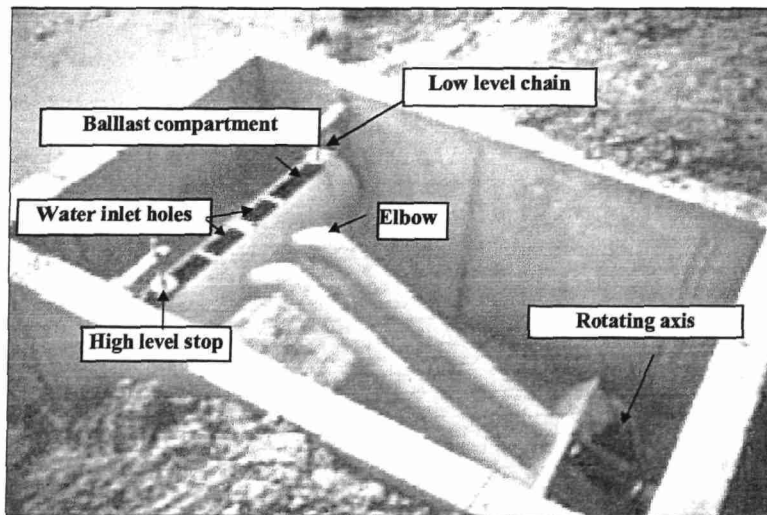


Figure 1 : Description of the Joudes SINT siphon.

The Joudes siphon, as described in Fig. 1, is composed of:

- a float with 2 water inlet holes (200 cm² each),

- 2 ballast compartments,
- 2 bent plunging tubes [elbows] which are constituting the real siphons terminated by evacuation tubes (diameter 110 mm).

The total float pivots on an horizontal mechanical axis which is fixed to the equipment concrete slab apron and connected to the outlets by flexible sleeves. Its movement is limited by high and low limit stops. As it is not standard and as it is customized for the specific characteristics of the different sites, clear self-primings and un-primings can be guaranteed. In this particular case, the siphon has been conceived in order to function on very small heights of tidal range but with a flow of $90 \text{ m}^3 \cdot \text{h}^{-1}$ for a correct water repartition on the filters surface (90 m^2 each) [6].

It can be noticed that, during this follow-up, rains have had variable intensity and an intense freezing period occurred. The storage basin surface and the siphon get covered by ice. The study ended after the thaw. During the study, we have been surprised by the climatic phenomena, relatively seldom in this region, and unfortunately outside temperatures have not been recorded. Table 2 gives the follow-up periods and the major climatic events.

Table 2 : Siphon operating conditions during its follow-up of 1998.

	Tidal range	Follow-up period	Climatic events
Phase 1	1,4 cm	from October 25 to November 3	Important rain
Phase 2	2,6 cm	November 4 and 5	
Phase 3	0.6 cm	from December 4 to 8	Freezing Thaw Rain
			October 28 and 29, November 1 and 2 December 7 to 9 After December 10 December 11

RESULTS

ISF CERTINES pilot

Effluent quality

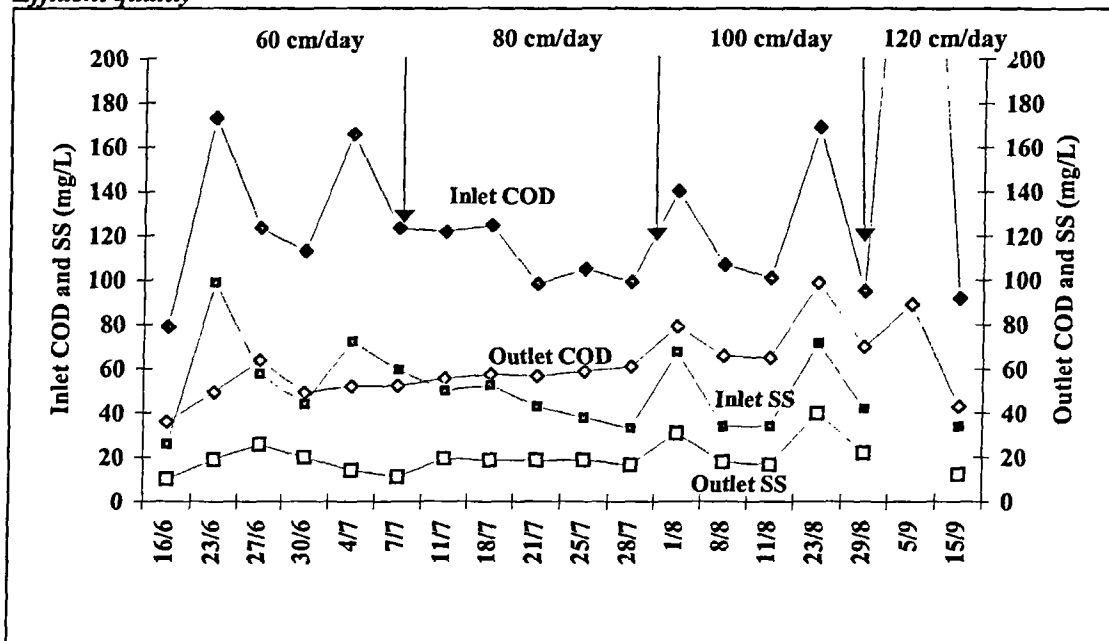


Figure 2 : SS and raw COD concentrations variations at pilot inlet and outlet.

Figure 2 shows SS and COD evolution, at the pilot inlet and outlet, in relation to the time and during of the 4 hydraulic applied loads phases. Table 3 shows the positive influence of the filtration across 27 cm sand height on effluent quality for all phases.

For COD and SS, higher input concentrations were expected but these low values can be explained because the plant is under loaded for the organic matter treatment. Average values do not exceed 135 mgCOD.L⁻¹ and 50 mgSS.L⁻¹; but the COD coefficient of variation is large (52%) and reveals an important variability of the effluent quality coming from the 2nd pond.

Table 3 : Concentrations variations at ISF pilot inlet and outlet.

Parameters	Number of measurements		Inlet (mg.L ⁻¹)		Outlet (mg.L ⁻¹)	
SS	17	Average	50		20	
		min-Max <i>std. dev.</i>	26 - 99	19	10 - 40	7
COD	18	Average	135		61	
		min-Max <i>std. dev.</i>	79 - 398	71	36 - 99	16
COD _f	17	Average	57		41	
		min-Max <i>std. dev.</i>	39-95	15	27-63	11
N-NH ₄ ⁺	7	Average	15.25		3.55	
		min-Max <i>std. dev.</i>	13.5-18.25	2.2	0.1-6.7	2.6
N-NO ₃ ⁻	7	Average	0.15		9.8	
		min-Max <i>std. dev.</i>	0.05-0.6	0.2	0.55- 18.1	7

At the pilot outlet, the effluent average concentration is notably below 90 mgCOD.L⁻¹ and 30 mgSS.L⁻¹. In addition, the standard deviation (*std. dev.*) attests an actual quality stability. The presence of nitrates, in very variable concentrations during the feeding cycle (1 to 18 mg.L⁻¹ N-NO₃⁻) is the proof of a well oxygenated media. During this survey, the few measurements done on the effluent have shown that the Kjeldahl nitrogen content never exceeded 10 mg.L⁻¹. The clear decrease, as measured on the ammoniacal nitrogen, is adding to the hypothesis of a quick nitrification.

The biological activity of this filter is also proven by a slight COD_f decrease of which average yield is around 25% (Table 4).

On the yield point of view, the results of table 4 are confirming that a sand height of 27 cm can retain in average just a little bit less than 60% SS and 50% COD. The yield stability can be confirmed by the *std. dev.*

Table 4 : ISF pilot yields

Parameters	Number of measurements		Yields (%)	
SS	17	Average	59	
		min-Max ; <i>std. dev.</i>	44 - 81	12
COD	18	Average	50	
		min-Max ; <i>std. dev.</i>	26 - 78	13
COD _f	17	Average	26	
		min-Max ; <i>std. dev.</i>	5 - 42	12

The outlet concentrations could not help to point out the influence of the applied hydraulic load on the final effluent quality.

Some samplings, done downstream the third pond, are confirming the interest of ISF vs. this third basin for the organic matter elimination. Effluents global nitrogen contents are equivalent. The main interest of the filters is to ensure a better nitrification, while WSP rejects the nitrogen compounds as organic and ammoniacal elements.

Influence of hydraulic and organic loads on ISF clogging

The survey of infiltration speed has been very fruitful. It has shown clearly the uneven decrease of the infiltration speed during the feeding period. After a rest period, the speed is coming back to a value which is higher than at the end of the previous cycle. Therefore, it is mandatory to maintain alternate feeding even for effluents previously treated in facultative ponds which are less concentrated in soluble organic matter than ones only mechanically treated in a settlement tank.

During August, infiltration speed progressively decreased from 1 250 mm.h⁻¹ to 995 mm.h⁻¹ in 5 weeks. This infiltration speed decreased for the same applied hydraulic load (1m³.m⁻².d⁻¹) and for a stable organic load (in average 30,6 gCOD.m⁻² per batch with a std. dev. of 7,8 ; these values are based on 15 measurements). With such an applied load, the evolution of infiltration speed indicates a gradual filter aging, linked to a building up of organic matter in spite of the half week rest periods which seem to be too short.

A few days later, in September, with a higher hydraulic load (1,2 m³.m⁻².d⁻¹), the filter clogged. This clogging is not only due to this higher hydraulic load. Climatic conditions, in September, were not as favourable as before for a superficial drying-up; but the key parameter, leading to clogging, seems to be the very high organic load (119 gCOD.m⁻² have been measured on one of the batches September 5).

For a future project, for a reliable operation, it would be judicious to have an average surface organic load of 30 gCOD.m⁻² per batch. In order to limit at best clogging risks, the highest acceptable surface organic load for a batch should be 90 gCOD.m⁻². For the Certines site, these values request the construction of 2 filters with a total surface of 0.8 m².PE⁻¹ fed by 4 daily batches of 20 m³.m⁻².d⁻¹.

JOUDES siphon

Evacuation flow

The siphon flow has been measured 4 times during phase 1 when its average tidal range was measured at 1,58 cm. The average evacuated volume (2,93 m³) for an average time of 142 s is corresponding to an average flow of 73,4 m³.h⁻¹. This value is actually almost 20% lower than the nominal value which is 90 m³.h⁻¹. Visually the water repartition on the filters surface is correct and does not look like affected.

Tidal range survey

Table 5 gives the tidal ranges during the 3 settings.

During phase 1, the average measured tidal range is very close to the one expected (1,368 cm vs. 1,4 cm). The siphon tips up at a stable height (std. dev. 0.1%) ; the float position when tipping-up is regular. The un-priming level shows more variability (std. dev. 0.3%) but can globally be considered as stable.

Nevertheless, some abnormalities are leading to significant variations of the tidal range. It is due to batches backing up lately in the siphon. They appeared with a frequency of 5,8% (9 batches per 156). This phenomenon can be explained by imperfect self-priming what does not allow a complete air evacuation in the high part of the evacuation tubes elbow and to reach the maximum flow. The un-priming, which happens when the water flow into the water inlet holes becomes below the evacuation flow, is happening then with a flow lower than normal, what is corresponding to a lower water level.