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Assessment of performance wastewater treatment by infiltration-percolation: a case study

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Abstract:

The recycling of wastewater is felt like a need, on the one hand to protect the receiving mediums and on the other hand, to be re-used for various uses (refill of the groundwater, irrigation….). To allow the development of the treatment of wastewater, the infiltration percolation can in this context, to represent an interesting alternative. This technique of purification combined with the Anaerobic Engine with Submerged Bacterial Bed (RALBI) developed at the point by laboratory BIOMARE of the Faculty of Science of El Jadida has for increasing the performances of treatment of the known as engine.

The results of the complementary treatment by the infiltration-percolation made it possible to remove the effluent from engine RALBI from its suspended matter and to decrease its organic, nitrogen, and phosphor load and of its microbial flora. The averages of results of specific analyses are all in lower part of the thresholds of reference.

Keywords: wastewater, treatment, infiltration-percolation, RALBI, bioreactor, El Jadida, Morocco

1. Introduction

More than half of the people now live in urban areas and the development of mega-cities is accelerating, particularly in emerging countries such as Morocco. In this context, the problem of sewage is crucial. If they are not collected and cleared, they are a vector health insecurity and degradation of ecological balance. By cons, treated strictly and properly, they can be reused for different purposes (groundwater recharge, irrigation ....) as an alternative resource.

Infiltration percolation, used to output additional treatments treatment plants to reduce the residual pollution and protect receiver settings can in this context, represent an interesting alternative. In fact, this technique of treatment, inexpensive and easy to maintain, allows the production of water suitable for groundwater recharge and irrigation (Preul, 1988; Boutin & Prost, 1989; Cherier, 1991).

This work is particularly interested in modelling this scrubber technology in his suit to bed reactor Anaerobic Bacterial Immersed (RALBI) developed by the laboratory BIOMARE Faculty of Science El Jadida to increase performance treating said reactor.

2. Materials

The treatment process consists of:

- Pre-treatment (Rake + settling basin)
- RALBI reactor (anaerobic bacterial bed reactor submerged) (Fig. 2)
- A storage device / injection (book tarp) and distribution (surface drains)
- Biological treatment of infiltration-percolation on sand is composed of three filter beds, a service, the other two rest, alternating weekly
- Points **E1** and **E2** parameter measurements to the input (E1) and the output (E2) of the basin infiltration-percolation (Fig. 1).

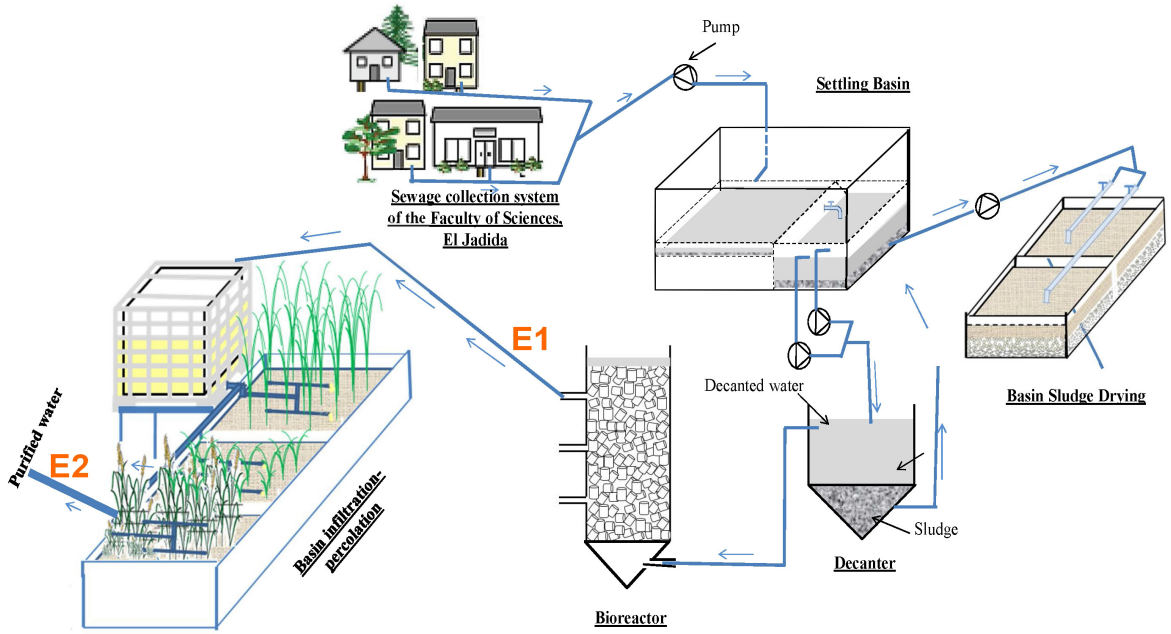

Figure 1. Components of the wastewater treatment system

Figure 2. Reactor RALBI and Infiltration percolation basins (before filling (a) and after filling (b))

2.1 Filter bed

The gravel pack is formed of a superposition of layers of materials of increasing particle size to a height of 100 cm with a thickness at the top of sand or too thin to avoid clogging, nor too large to avoid a too fast.

This massif is composed of several materials: river sand and alluvium calibrated.

Characteristics of the sand are as follows:

- 0.25 <d10 <0.4 mm
- CU (uniformity coefficient = d60/d10) of between 3 and 6

- maximum fine in 2.5%

2.2 Feed basin

It is produced by tarpaulin to best distribute the effluent (water film 10 cm) over the entire surface due to basins March to June Curtainsiders daily.

2.3 Ventilating

Ventilation filters is facilitated by the presence of "ventilation shafts" for the transit of oxygen to the bottom of the mountain.

3. Analytical methods

➢ *Physico-chemical parameters*

The TSS, BOD_5, COD, TKN, Ammonium nitrogen (NH_4^+), Nitrate (NO_3^-), Total Phosphorus (TP) and orthophosphate (PO_4^{3-}), were analyzed in the laboratory according to the methods prescribed in AFNOR (French national organization for standardization) handbook (AFNOR, 1999, 2001a).

➢ *Bacteriological parameters*

The bacteriological analysis of the various samples of waste water consists of an enumeration of the indicator germs of fecal contamination to know fecal coliforms (FC) and enterococci (SF):

- Enumeration of fecal coliforms

Fecal coliforms or thermotolerant coliforms are a sub-group of total coliforms able to ferment lactose at a temperature of 44.5°C.
The most important species of this bacterial group is *Escherichia coli* (*E. coli*) and to a lesser extent some species of the genera *Citrobacter, Enterobacter and Klebsiella* (EMMANUEL *et al.*, 2008; Salama *et al.*, 2014).
The spatio-temporal evolution of the abundances of CF was assessed by counting the colonies on the yellow-orange Tergitol agar and triphenyl tetrazolium chloride (TTC - Tergitol 7). The inoculated petri dishes were incubated at 44.5 ° C for 24 hours (AFNOR, 2001b).

- Enumeration of enterococci

Enterococci bacteria are spherical, in pairs or chains, Gram positive, catalase-negative, facultative anaerobic, which hydrolyze esculin in the presence of bile (Moutoussis *et al.*, 1960). This test is characteristic of bacteria in group D Lancefield. Under the general description of enterococci (fecal streptococci) and according to WHO, fecal streptococcus are largely of human origin. However, some bacteria of this group were also collected from feces of animals such as Streptococcus bovis, S. equinus, S. gallolyticus and S. alactolyticus (Clausen *et al.*, 1977), or even meet on plants. They are still considered indicators of fecal pollution, and their main interest lies in the fact that they are resistant to desiccation and persist longer in water (Gleeson & Gray, 2002). They thus provide additional information on pollution. The presence of enterococci was evaluated by counting black colonies with black halo on the agar medium in the bile, esculin and sodium azide, after incubation at 37 ° C for 48 h (Salama *et al.*, 2014).
It is important to mention that the value of the report fecal coliform / fecal streptococci is used as an informative element of the first order. Indeed, when it is greater than 4, the pollution is of human origin. When this ratio is below 0.7, the pollution is of animal origin (Geldreich & Kenner, 1969). However, this ratio is not recommended unless the contamination is really recent.

4. Results and discussion

The results of monitoring the various parameters of pollution taken to the influent (E1) and to the Effluent (E2) of the basin infiltration-percolation as shown in Table 1:

Table 1. The average values of physicochemical and bacteriological parameters studied between 2010 and 2011

Parameters	Influent (E1)	Effluent (E2)	% Reduction
TSS (mg/L)	0.16	0.06	62.5
COD (mg/L)	132	36	72.72
BOD_5 (mg/L)	22.17	1,17	94.72
NH_4^+ (mg/L)	30.6	5.4	82.3
TKN (mg/L)	32.2	4.2	87
Nitrite (mg/L)	55.86	37.87	32.18
Total Phosphorus (mg/L)	0.11	0,05	54.54
Fecal Coliforms (UFC/100 mL)	1.4×10^6	10^2	4 Ulog
Fecal Streptococci (UFC/100 mL)	8.1×10^3	40	2 Ulog

4.1 Total suspended solids

Effluent entering the basin infiltration-percolation contain 0.16 mg/L of Total suspended solids (TSS) which are almost all held in the first centimeters of the soil. Indeed, percolating through the solid effluents are first cleared of Total suspended solids. Retention mechanisms of Total suspended solids were studied by Corapcioglu and Halidas in 1982 (Schmitt, 1989). They indicate two mechanisms to explain the retention of a particle in a porous medium:

- A blockage in the pores,
- The interception and its attachment to the grains of the porous medium.

However, particularly in the case of heavily loaded effluent, TSS can cause major clogging problems (5.15).

4.2 Organic matter

The organic effluent load to the input of infiltration-percolation basin is characterized by a BOD_5 of 22.17 mg/L and a COD of 132 mg/L at the output of the basin. On the other hand the values of BOD_5 and COD recorded in the output basin are respectively 1.17 and 36 mg/L.

This reduction is explained by the fact that the soil purifies with a very good efficiency organic matter brought by the effluent are oxidized under the action biodégradatrice microorganisms (Salama Y., 2013). Yields observed for the purification of carbon are still very high (> 90%) and for types of waste and the conditions of application variables (Soulié & Tréméa, 1991; Salama Y., 2013).

4.3 Organic nitrogenous matters

Yields of nitrogen removal observed range from 32% to over 87%. These results are consistent with those found in U.S. facilities infiltration percolation have removal efficiencies of nitrogen between 10 and 93% (Cherier, 1991).

The nitrogen is found in the effluent in various forms which can be separated into one of the following two classes (Rousselle, 1990):

- Organic Nitrogen: proteins, amino acids.....
- Mineral nitrogen: NH_4^+, NO_3^-, NO_2^-.

The complete oxidation of nitrogenous material in a filter bed is following the sequence of reactions ammonification, nitritation and nitration (Gholamifard, 2009). During infiltration-percolation of wastewater, ammonium is determined by the complex soil absorption and nitrified during the drying promotes soil aeration. Denitrification can then occur when the next flood if anaerobic conditions exist or if the nitrified nitrogen is driven in a poorly ventilated deep horizon.

4.4 Phosphorus matters

The effluent at the inlet of the basin containing 0.11 mg/L of phosphorus, mainly forms polyphosphates (PO_3^-) n and organic degradation of organic matter resulting in the release of orthophosphate PO_4^{3-} (SOLTNER, 1983).

The efficiency of phosphorus removal observed is 54.54 % which is consistent with the work of Cherier (Cherier, 1991) who found that the average retention of phosphorus measured on experimental sites was approximately 40

to 50 %.

This removal of phosphates in devices infiltration percolation occurs by two essential ways:

- Either by assimilation by microorganisms,
- Either by fixing the filter material (fixation occurs due to the presence of certain elements in the filter bed telque Fe_3^+, Al_3^+, Ca_2^+) (Gougoussis-Delpy, 1982).

4.5 Micro-organisms

Wastewater carry a large number of pathogens such as parasites, bacteria and viruses (BERRON, 1984; Prost & Boutin, 1989; Altmeyer *et al.*, 1990; Youssef *et al.*, 2012). Yields purifying FC and FS are 4 and 2 Ulog. The percentage removal during infiltration-percolation is a function not only of retention but also their ability to survive in the filter bed (Billaut, 1989). Retention mechanisms of these germs are filtration (bacteria and parasites) and sedimentation of bacteria in the pores, and adsorption (bacteria and viruses) on the complex of soil (Moreau, 1993).

The elimination of micro-organisms is important in the soil, pests and their eggs are effectively filtered even a significant part of bacteria and viruses adsorbed on suspended solids (Brissaud *et al.*, 1990). However, there are possibilities of transport of bacteria and viruses in the soil are largely a function of soil characteristics from those of the effluent, application method and climatic conditions (rainfall) (Brissaud *et al.*, 1990). There are differences depending on the microorganisms, but it appears that bacteria can be retained in the top few centimeters of soil (Jemali & Kefati, 2002).

5. Conclusion

Infiltration-percolation system is a wastewater whose operating characteristics are already well known, and the experimental study was conducted in the Faculty of El Jadida was intended to be a first test in an area where this technique could lead to opportunities for wastewater recycling very interesting. Indeed, the infiltration-percolation helped rid the effluent from the reactor RALBI its suspended matter and reduce its organic load, nitrogen, phosphorus and its microbial flora.

This treatment system infiltration-percolation process combined RALBI has thus reduce the pollutant load to the maximum and to respect the values set by Moroccan standards.

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