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Influence of secondary salinity wastewater on the efficiency of biological treatment of sand filter

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Abstract

As preventive of possible environmental nuisances that can cause discharges water in nature, we undertook this study of the influence of salinity wastewater on the treatment efficiency of a biological filter consisting of dune sand.

In this work, we designed six identical columns of filtration with sand from the same region of the N'Goussa city (located in the southeast of Algeria). The filters used are fed with wastewater at six different total salinity rates ranging from 0.065% to 0.265% corresponding to the electrical conductivity of 0.85 mS/cm to 3.5 mS/cm. This filtration efficiency was assessed by monitoring changes in the conductivity and the overall pH of the treated water and the chemical oxygen demand (COD). The results obtained showed that the change in the salinity of sewage water has a negative effect on the degradation of organic matter. Indeed, over the salt content is high, over the effectiveness of the biological treatment is reduced, suggesting in this type of case a prior desalination system and tests are under way in our laboratory.

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Keywords: biological filtration, treatment of wastewater, salinity, washed sand, purification yield.

1. Introduction

During the biological treatment of wastewater, increase in salt concentration results in reduction of biodegradation rate. The presence of salts may cause inhibition and toxicity problems in the methanogenic activity or dehydrate bacterial cells because of osmotic effect or inhibit one or more of the reaction pathways in the substrate degradation process.

In non-saline conditions, the bacteria are known for their varied metabolism. But little information exists with regard to their potential for aerobically degrading polluting molecules under saline conditions[1].

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Saline loads affect the metabolic functions of micro-organisms and reduce the kinetic degradation in activated sludge. It seems that some acclimatization of micro-organisms to habitats with relatively high saline concentrations is to be expected[2]. There have been many studies on the treatment of saline and hypersaline wastewaters (>3.5% salt) in constant concentrations or high- polluted groundwater's. However, in conventional biological processes can't be used to treat wastewater containing more than 3-5% salt[2-3]. Saline wastewater is usually treated through physic-chemical treatment processes. Alternative unit processes for saline wastewater treatment include anaerobic or aerobic biological treatment. However salinity is known to have toxic effects on bacteria and is also capable of altering microbial characteristics.

Major problems encountered in biological treatment of saline wastewaters were:

- Salt adaptations of cultures were easily lost when subjected to salt free-medium
- Changes in ionic strength cell disruptions due to shifts in salt concentration from 0.5 to 2%, caused significant reductions in system performance.
- Rapid changes in salt concentrations created adverse effects more than gradual changes[4].

Normalization to constant salt concentration in essential before saline wastewaters were treated. Thus available information indicated that the removal of BOD by biological treatment processes is reduced at salt concentration above 8,000 mg/l[3].

In this study, pilot scale trials were carried out to treat different salinity wastewater on conventional biological treatment by filtration on sand dune with reference to COD removal with the following parameters: pH and conductivity.

2. Materials and methods

2.1. Analytical methods

- Measured the pH by (PHS-3E) and EC by (DDSJ-308A);
- For measuring the organic material MO, the Anne method was used; according to AFNOR standard (X 31-109) [10].
- Measuring the rate of limestone is made using the BERNARD calcimeter [10].
- The particle size curve of N'goussa washed sand has been prepared by passage through a series of sieves according to AFNOR standard (NF 1996) modified (lack of 0.400 and 0.250 screen).
- determined the chemical oxygen demand (COD) by the colorimetric method [10].

2.2. Effluent qualities

The conductivity of a wastewater in highly variable from one region to another depending mainly on natural mineralization of drinking water[5]. From this, the waste water samples have been systematically compared to the composition of domestic ones which were taken as a reference. Therefore, different concentrated solution made of mixtures of chemicals and alimentary products have been prepared[6]. This latter was used as a reference for the five other synthetic wastewaters when its EC≈0.87 mS/cm (0.036 g/l of $CaCl_2.2H_2O$). We added $CaCl_2.2H_2O$ salt between 0.036 g/L and 2 g/L to increase the electrical conductivity of the wastewater between 1.5 and 3.5 mS/cm with a step of 0.5 mS/cm. The resulting synthetic wastewaters was dried overnight and characterized by (see table 1).

Table 1.Characteristics of the prepared wastewater

Characteristics	$CaCl_2.2H_2O$ (g/l)	Total salinity (g/l)	EC moy (mS/cm)	pH moy	COD moy (mg O_2/l)
EU01	0.036±0.002	0.656±0.030	0.870±0.064	5.56±1.23	687±91.2
EU02	0.48±0.03	1.10±0.06	1.50±0.075	6.22±0.82	654.4±117.6
EU03	0.87±0.03	1.49±0.06	2.00±0.166	6.24±0.85	659.2±93.6

EU04	1.20±0.04	1.82±0.07	2.49±0.220	6.28±0.80	653±151.2
EU05	1.60±0.02	2.22±0.06	3.00±0.240	5.93±1.10	662.4±153.6
EU06	2.00±0.03	2.62±0.07	3.50±0.285	6.33±1.13	651.8±150

Calcium chloride $CaCl_2.2H_2O$ was not recommended in similar topics, this is because it was found that the Na^+ has a bad effect on the permeability of sand in each filter, or excess sodium can be reducing the soil ability to transmit water[7]. It was also found that the main soil chemical properties that can be changed by wastewater and that could affect soil structure[8].

2.3. Granular media

It was recommended to use the sand dune of N'Goussa region (Ouargla) that has fine grain, uniform, slightly salty, poor in organic matter and alkaline pH with a low lime content, which gives good results in the field of biological filtration at the pilot scale; was chosen as a site for our investigations after washing with distilled water to minimize the maximum chemical properties. This work was a continuation of the previous series of comparative studies on this material and it has been adapted for purification by slow filtration[9]. The table 2 shown the difference between the N'Goussa sand naturally and washed N'Goussa sand

Table 2.Physic-chemical parameters of original N'goussa sand and a washed N'gouss sand.

Sable	N'Goussa	washed N'Goussa sand
EC25C° (mS/cm)	4.1700	0.0478
pH	8.60	9.04
Salinity (mg/g)	12.400	0.326
MO %	0.086	0.001
CaCO3 %	0.24	0.00
Real density g/cm^3	2.920	2.624

The measured values of pH and EC after the aqueous solution 1/5 g/L. The analysis thus showed that the N'Goussa washed sand is very lightly saline sand, alkaline pH, and is characterized by a rate of an organic material and limestone is zero. The Apparent density and porosity of the sand filter bed determined experimentally are equal to 1.561 g/cm^3 and 0.494.

2.4. filtring pilotes

The experiment was performed on 6 PVC laboratory columns 76 mm inner diameter 800 mm in height (Fig. 1). The columns were made of a scrubber massif with a draining massif. The thickness of the sand in each filter is 60 cm.

The scrubber massive is N'goussa washed sand whose diameter uniformity d_{60}/d_{10} of about 2.3 mm and the diameter classification Cc =d_{75}/d_{25} is 1.07. According to the results obtained, we find that used sand is uniform in size, tight and little graduated.

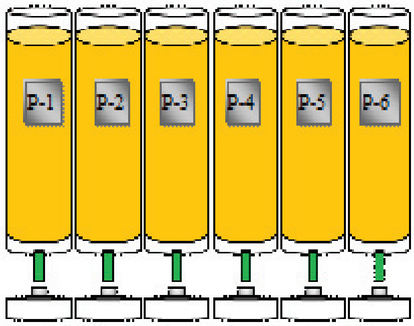

Fig. 1. filtering pilots

3. Results and discussion

Filtered wastewater sampling and their characterizations are made weekly for each pilot. The measured parameters are the electrical conductivity EC, pH, COD and temperature. This last parameter having a considerable influence on the nitrification and denitrification ([11], [12]), is measured daily; the values are between 22 and 27 ¨C. Before their introduction into the pilots of filtration, the saline waste water have the pH values between 5.56 and 6.33, this acidity (due to the presence of organic acid) disappears and filtering leads to basic pH values (table 03). This can be attributed to a fermentation phenomenon of organic matter under the effect of the variation of the temperature during filtration.

Table 3. pH values as function of time.

	Time (week)/pH						
Filter	1	2	3	4	5	6	7
P-1	8.25	8.32	8.18	8.06	8.29	8.13	8.01
P-2	8.36	8.31	8.15	8.05	8.19	8.13	8.15
P-3	8.16	7.93	8.17	7.84	8.14	8.15	7.81
P-4	8.3	8.13	8.19	8.09	8.18	8.25	8.23
P-5	8.31	7.96	7.98	7.94	8.21	8.21	7.96
P-6	8.59	8.47	8.17	8.42	8.37	8.33	8.54

The variation of electrical conductivity EC (table 4) is evaluated by the difference ΔEC = EC2 - EC1 (EC1: at the entrance and EC2: at the outlet of the filter). The results do appear two ranges of values: the first is that of good functioning (from the 1st week to the 5th week), while the second, corresponds to the wear of filters (from the 6th week to the 7th week).

Table 4.ΔEC values as function of time.

	Time (week) / EC (mS/cm)						
Filter	1	2	3	4	5	6	7
P-1	0,38	0,4	0,46	0,55	0,53	0,39	0,13
P-2	0,33	0,3	0,39	0,24	0,44	0,15	0,13
P-3	0,26	0,29	0,42	0,35	0,46	0,16	0,39
P-4	0,34	0,21	0,30	0,26	0,40	0,17	0,16
P-5	0,30	0,24	0,17	0,55	0,36	0,18	0,14
P-6	0,28	0,31	0,20	0,38	0,35	0,11	0,33

During the first step, there is a slight ΔEC evolution which stabilizes over time. This is mainly due to an increase in the rate of salts from the transformation of organic matter in dissolved salts. During this first stage, filtrates EC values are always greater than the values of saline wastewater, reaching the threshold of 0.35 mS/cm at 0.53 mS/cm for different pilots at the end of the 5th week. This highlights other sources of soluble salts by effect of common ions for example (impact related to the composition of the treated effluent) or by microbial activity during maturation of filters.

In the second part, cited above, the ΔEC, measured at the beginning of the wear period, is slightly low, it ranges from 0.11 mS/cm to 0.39 mS/cm for the different pilots in the 6th week, then this trend is reversed for some pilots in the 7th week, from 0.13 mS/cm to 0.39 mS/cm. This illustrates the appearance of the phenomenon of clogging of the filters by the organic load and precipitated salts.

Removal yield of COD during 7 weeks of operation, is shown in figure 02. From the point of view of the removed load, good yields are obtained at the beginning of the work which can be explained by the adsorption of organic matter on the filter material and the persistence of bacterial activity despite variations in the concentrations imposed with components of wastewater samples, during the two weeks. This phenomenon can be justified by the likely formation of biofilm especially at the level of the superficial layer of the pilots, which promotes the decantation of organic matter. This aspect appears clearly between the 3rd and the 6th week, where the evolution of the COD indicates good performance of removal of organic matter. Beyond this period (6th - 7th week), the results of COD remain acceptable despite the wear of filters.

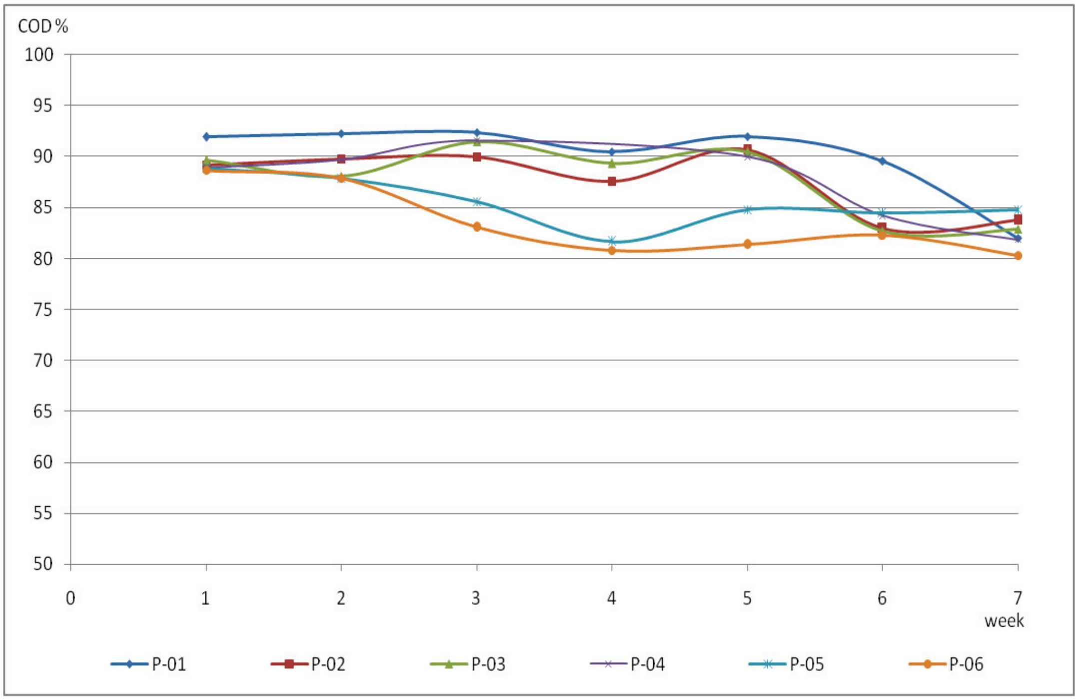

Fig. 2.Time-courses of COD yields.

Moreover, it was also found a comparable efficiency of COD removal at the salt concentration varying from 0.65 g/l to 2.62 g/l , and a good biodegradability of wastewater was observed with salt tolerant bacterial in 0.65 g/l (see fig.2 P-01). Increase in salt concentration to 2.62 g/l resulted in deterioration of the treatment process and COD reduction (see fig.2 P-06).

In this work, we used wastewater with a rate below 3% salt, because authors have reported that wastewater with rates ranging between 3 and 5% salt, may not be effectively a conventional biological treatment ([2], [3] and

[15]). They showed that the rate of biological degradation of organic compounds can be reduced by increasing the salt content. Furthermore, the presence of salts can cause inhibition of the bacterial activity due to the osmotic effect in the process of aerobic biological treatment of saline wastewater [16].

The biological filtration is, without doubt, one of the most effective methods of rapid purification of used water by aerobic microbial oxidation. Traditionally, treatment by infiltration is a method for tertiary treatment of sewage, and as a method of secondary treatment of industrial wastewater [17]. But because of its hardiness, it is available for the treatment of primary wastewater in Africa, where, more often, waters are released untreated into the natural environment [18].

4. Conclusion :

To assess the effectiveness of the biological filtration technique, our work of treatment of synthetic saline wastewater, with six different rate salt levels (between 0.065% to 0.265%), on a washed sand filter, confirmed the possibility of treatment of wastewater containing less than 1% salt by this process, with a very interesting performance, since COD > 80% yields are obtained.

Activity of microorganisms in the process of filtration, proves to be dependent on several factors, such as the type and phase wastewater supply, as well as rapid or gradual salts concentration increased during operation. The results obtained in this work indicate an inverse relationship between the salinity of sewage and purification performance in a biological filter, highlighting the problem of salinity wastewater on the efficiency of treatment by this method.

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