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AEROBIC REACTOR WITH FIXED SUPPORT USING PET BOTTLES

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María Yesenia Mendoza Burguete [1], José Alberto Rodríguez Morales [2]

[1] men_bur@hotmail.com • [2] josealberto970@hotmail.com
Faculty of Chemistry, Autonomous University of Querétaro, Campus Aeropuerto, Santiago de Querétaro, Querétaro, CP 76010, Mexico

— Abstract—

The wastewater treatment is implemented worldwide using variety of systems to remove pollution because they are harmful to living beings. Therefore, the objective of this study was to construct and use a 90 liter rectangular biological reactor with aeration that contained PET (polyethylene terephthalate) plastic bottles. Inside the reactor the surface of these bottles were used as means for the production of a biofilm to be later used for treatment of domestic wastewater. During the experiment, influent and effluent water was monitored. In order to evaluate the quality of the mechanism, the removal of the Biochemical Demand of Oxygen (DBO_5) and Chemical Demand of Oxygen (DQO) were measured. The biochemical demand of oxygen was 97.7% and the chemical demand of oxygen was 97.6%. The average treatment time was 2.72 hours.

Keywords

Biofilm, domestic water treatment, polyethylene terephthalate.

Biofilm has been successfully used in water treatment for more than a century (Atkinson, 1975); however, the advantages of this type of process were of interest to a considerable number of researchers in the 80s, Not only in the field of wastewater treatment, but also in many other areas related to biotechnology (Adler, 1987, Yang et al., 2013). A large number of research projects are currently underway in biofilm reactors for the production of bioactive substances for plant and animal cell cultures, potable water production and wastewater treatment (Castro et al., 2016; McNaught And Wert, 2015, Hu et al., 2013, Vendramel et al., 2015, Gu et al., 2014).

A key advantage of biofilm processes is the positive influence of solid surfaces on bacteria. This activity was observed more than 50 years ago (ZoBell, 1943) and recently confirmed by other researchers (Bassin et al., 2012, Mohan et al., 2013, Dong et al., 2014; Park et al., 2010; Dvořák et al., 2014). There is considerable debate about the mechanism that induces greater activity of fixed biomass, (Rusten et al., 2006; Wang et al., 2006). Some authors (Zhan et al., 2006; Hibiya et al., 2004; Jorgensen et al., 2004; Yan et al., 2009) attribute this phenomenon to physiological modifications of bound cells. It has been shown that biomass processes with fixed support media are less affected than suspended sludge by changes in environmental conditions such as temperature, pH, nutrient concentrations, metabolic products and toxic substances (Tansel et al., 2006; Utgikar et al., 2002).

The activity of the biofilm is not proportional to the amount of biomass, but increases with the thickness of the biofilm to a certain level, known as the "active thickness" (Remoundaki et al., 2008). Above this level, nutrient diffusion becomes a limiting factor, differentiating an "active" biofilm from an "inactive" biofilm. Consequently, a stable, thin and active biofilm offers numerous advantages in water and wastewater treatment. In order to achieve this objective, it is important to develop methods for the activity of fixed biomass, an estimate that is not only simple and fast but also sensitive, accurate and representative.

In the present investigation the efficiency of an aerobic biological system using polyethylene terephthalate (PET) bottles as support medium to facilitate biofilm production for the treatment of domestic wastewater was analyzed and evaluated.

MATERIALS AND METHODS

Construction of the aerobic biological system and preparation of the support medium.

The rectangular glass reactor -50 cm wide, 61 cm long and 31 cm high- was constructed with PVC adaptations to facilitate aeration, feed and exit of the treated water as shown in Figure 1. The inside contains PET bottles (polyethylene terephthalate) geometrically ordered with small incisions in the walls of the support medium to allow the flow of water.

Figure 1. Aerobic reactor with PET bottles as medium of support.

Biomass acclimatization

50 liters of activated sludge from the wastewater treatment plant of the Universidad Autónoma de Querétaro, Campus Aeropuerto located on the Chichimequillas Highway, Ejido Bolaños, Querétaro, Qro. CP 76140, were emptied into the aerobic biological reactor. as shown in Figure 2 and fed with 40 liters of residual water from the Faculty of Languages and Literature and Gastronomy of the same university.

Figure 2. Inoculation of activated sludge to the aerobic reactor for biofilm production.

Biofilm Production

These 90 liters of activated sludge and wastewater were discharged into the reactor for inoculation, production and biomass fixation, and to begin the process of adhesion and biofilm formation which was obtained after three weeks. After this time several physicochemical studies were carried out at the entrance and exit of the system to determine the efficiency of the system, gradually increasing the concentration of pollutants from the waste water. The daily indicative analyzes showed a removal of between 70 and 85% in the first 25 days.

Physicochemical analysis

Every day for 30 days after biofilm was produced, 60 liters of treated water was obtained and 60 liters of residual water were administered. For the genetic strengthening of microorganisms, different wastewater conditions were fed, as shown in Table 1. In this table three analyses of different influent waters are observed and in turn were compared with the Official Mexican Standard NOM-003 -SEMARNAT-1997, which establishes the maximum permissible limits of contaminants for treated wastewater that are reused in public services.

Table 1. Results obtained from physicochemical analysis of the influent of aerobic biological system.

Determinación		Influentes		Max. Perm	Unidades
Demanda Química de Oxígeno	332	409.2	782	N.E.	mg/L
Demanda Bioquímica de Oxígeno	204	219.96	600	20	mg/L
Sólidos Suspendidos Totales	168	298	500	20	mg/L
Grasas y aceites	3	3.2	25	15	mg/L
Coliformes Fecales	23	≥2400000	≥2400000	240	NMP/100 mL
Huevos de Helmintos	Ausente	Ausente	Ausente	≤1	Organismos/L

Max. Perm. According to the NOM-003-SEMARNAT-97.
Results according to Chemical Services Center, No. Accreditation: AG-160-027 / 12
NS: Not specified.

RESULTS AND DISCUSSION

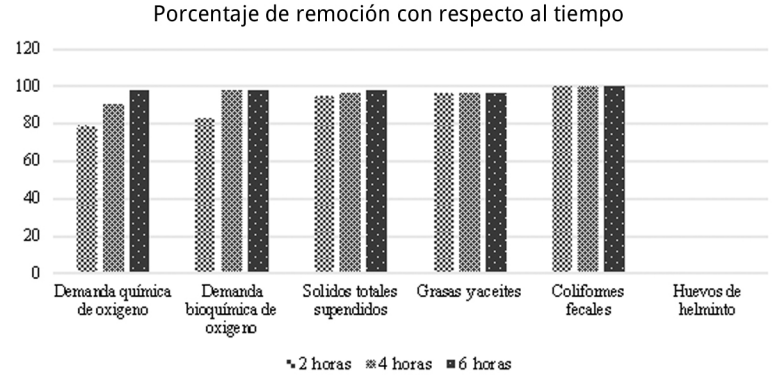
The subsurface support have proved to be highly efficient in removing COD and BOD in waste water (Osorio and Hontoria, 2001) and the results of this study prove it . This system can be adapted to plants built with little soil disposal (Bassin et al., 2012), and one can even increase the treated flow rate since a high solids concentration is maintained inside the reactor, and that for this study the contact area surface of the biofilm in the reactor was 5.74 m 2. One of the main problems of conventional treatment plants is the influence of flow and quality of the influent, and a solution is the implementation of aerobic biological biofilm reactors (Tóth & Szilágyi, 2013). Table 2 and Figure 3 show the results of the physico-chemical analysis of the residual water in which, after 4 hours of treatment, NOM-003-SEMARNAT-1997 was achieved. However, after 2 hours, it exceeded 80% of these pollutants.

Table 2. Results obtained from physicochemical analysis of influent and effluent at different times.

Determinación	0 horas	2 horas	4 horas	6 horas	Unidades
Demanda química de oxígeno	782	169.5	74	18	mg/L
Demanda Bioquímica de Oxígeno	600	101.37	15.83	14.66	mg/L
Sólidos suspendidos totales	500	26	20	12	mg/L
Grasas y aceites	25	<1.0	<1.0	<1.0	mg/L
Coliformes fecales	≥2400000	<3	<3	<3	NMP/100 mL
Huevos del Helminto	0	0	0	0	Organisms/L

Max. Perm. According to the NOM-003-SEMARNAT-97.
Results according to Chemical Services Center, No. Accreditation: AG-160-027 / 12
NS: Not specified.

Figure 3. Analysis and comparison of percentage removal of some parameters at different times, (pH = 7.1 ± 1, T = between 23 and 25 o C).



The support material with PET plastic used in this study was successful for the development of microorganisms and fixation of biomass. In general, the biofilm is hard to fix (Battin et al., 2007; Mongenroth and Milferstedt, 2009), although there is scientific evidence on the adhesion of biofilm to polyethylene terephthalate in marine waters, where satisfactory results and

experimentation were obtained as a means of support for other types of studies (Hayden et al, 2008;. Kishu et al . , 2009).

CONCLUSIONES

The aerobic biofilm system with polyethylene terephthalate bottle support medium is a simple system, easy to operate, and does not need large spaces for its construction. The microenvironment of the biofilm offers shelter to many species of microorganisms, promoting the use of a wide range of substrates, it supports variations in flow, among other advantages. Physicochemical results of this system compared to the maximum permissible limits established in the Mexican Official Standard NOM-003-SEMARNAT-1997 met in an average time of 2.75 hours with a percentage removal for COD: 88.86%, BOD 5: 92.69% , SST: 96.13%, Fats and oils: 96%, Fecal coliforms: 99.99%. From this it is concluded that the system is viable, economical and efficient for the treatment of domestic wastewater.

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