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EXTENDED ABSTRACT

Removal of 4-Nitrophenol Contaminant by Moving Bed Biofilm Reactor with Media Bee Cell 2000 and Shock Study

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1. Introduction

Today, the population of most countries is growing exponentially. Countries whose main economic dependence is on oil production. This issue, along with the lack of a rational management system for increasing fuel consumption, groundwater resources and it has seriously threatened the environment in industrial hubs (Ghaderi et al., 2019). Of the various compounds of water pollutants that enter water sources mainly through raw wastewater and its effluents, phenolic compounds are of special importance and can even enter water sources naturally (Ghaderi et al., 2019; Ghaderi et al., 2020).

Nitrophenol, a member of the phenolic family of pollutants, is a carcinogen and is known for its many adverse effects on humans and aquatic animals. In recent decades, chemical reduction of nitro phenolic compounds has been widely reported as an advanced removal method for such hazardous dyes from reservoirs (Din et al., 2020).

Nitrophenols, which are toxic, inhibitory, and biodegradable organic compounds, are widely used in the chemical industry to make pesticides, dyes, and drugs, and are often found in the effluents of industrial wastewater treatment plants. (Ma et al., 2000).

2. Methodology

In the first place, it was piloted on a laboratory scale and then the sludge from the return line obtained from the municipal wastewater treatment plant was applied to the pollutant. Thus, at first, all the initial feed was in the form of glucose, and gradually the amount of glucose was reduced and the 4-nitrophenol contaminant was replaced. After adaptation, the removal of 4-nitrophenol contaminant by the reactor was investigated.

2.1. Pilot profile

The specifications of the pilot used are given in Table (1).

2.2. Media profile

Bee cell 2000 media was used to start the reactor with a moving bed. Table (2) presents the characteristics of the media used.

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Table 1. Reactor specifications used in the researchv

Plexiglas	Reactor material
5	Wall thickness (mm)
21	Inner diameter (cm)
22	Outer diameter (cm)
61	Effective height (cm)
90	Total height (cm)
31.156	Total volume (lit)
21.117	Effective volume (lit)

Table 2. Characteristics of acne used in research

Bee cell 2000	Parameter
Polystyrene	Media type
Honeycomb	Shape
950	Density (kg/m3)
White	Color
650	Specific area for biofilm growth (m2/m3)

2.3. Equipment

The main devices used were as follows:

- Spectrophotometer for measuring COD and concentration
- 4-Nitrophenol
- Digital scale with an accuracy of 0.001 g
- pH meter
- Furnace
- Avon to determine MLSS
- Aeration pumps (used in home aquariums)

2.4. Setting up the MBBR system

In order to launch the pilot, about one third of the bioreactor volume was filled with concentrated sludge prepared from the backflow of the activated sludge basin of the municipal wastewater treatment plant; the rest of the volume of the bioreactor was made up to 300 mg/L with a solution of water and glucose with COD. Also, after starting the bioreactor, a series of experiments were performed, the results of which are shown in Table (3).

Table 3. Specifications of sludge used to start the reactor

value	Parameter
7.2	pH
19	Temperature (℃)
1.4	Soluble oxygen (mg/L)
4112	Suspended liquid suspended solids (mg/L)
3331	Suspended volatile solids mixed liquid (mg/L)

2.5. Adaptation of microorganisms to synthetic wastewater

In the first stage, glucose compatibility with COD equivalent to 300 mg/l was injected into the system. Then, in order to adapt the sludge to the synthetic wastewater, in eleven stages, wastewater containing different concentrations of 4-nitrophenol contaminant was injected, so that in the second stage, COD equivalent to 300 mg/l was injected into the system; In the first loading of pollutants into the reactor, the share of organic pollutants and glucose was selected as 10% and 90%, respectively. Furthermore, the ratio of organic charge of 4-nitrophenol to glucose is 20+80, 70+30, 60+40, 50+50, 40+60, 30+70, 20+80, 10+90 and 100+0, respectively. Percentage was injected into the system (Fig. 1) and the COD removal efficiency at the end of the residence time (24 hours) at each stage was evaluated.

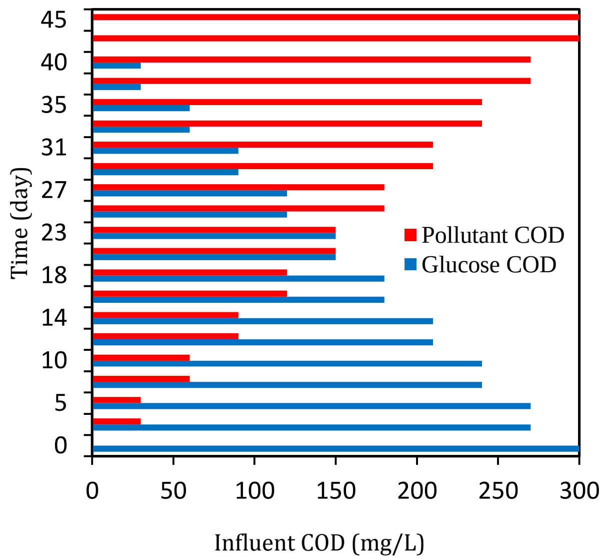

Fig. 1. Loading process in the compatibility stage (COD=300 mg/l)

2.6. Parameters examined in the main tests

At the end of the adaptation period, the main tests were performed and in this period the effect of the input COD level at the levels of 400, 500, 600, 800, 1000, 1500, 2000, 2500 and 3000 mg/l (at levels 8, 12, 24 And 48 hours) were studied and also the effect of reactor filling percentage (at three levels of 30, 50 and 70%) on the input COD equal to 1500 mg/l was investigated.

2.7. Evaluation of contaminant removal efficiency in case of input shock to the system

In this study, we investigated the effect of using acne on the shock rate of Bee Cell 2000 biological system of acne by increasing 2000 mg/l in the amount of COD entering the reactors (when the reactors reached less than 50% efficiency in the main tests). And how to return it to the previous condition was studied.

3. Results and discussion

3.1. Effect of increasing input load on COD removal efficiency

In the initial loading up to COD equal to 1000 mg/L, the removal efficiency in the reactor has a uniform decreasing trend, so that in COD equal to 600 mg/L this efficiency is equal to 77% in 24 hours, also in COD equal to 800 mg/L this Efficiency in 24 hours is equal to 71%. In COD equal to 1000 mg/L, the removal efficiency was observed to be equal to 68% at a residence time of 24 hours and these values were reduced by 6% for a COD equal to 1500 mg/L for a residence time of 24 hours compared to the input COD of 1000 mg/l. had. The highest removal efficiency is related to the input COD equivalent to 400 mg/L in the reactor containing the studied acne.

3.2. Investigation of the effect of different residual time on the removal efficiency of 4-nitrophenol

The removal efficiency of 4-nitrophenol during the operation period is shown in Fig. 2. Carefully in the diagram of a decreasing trend in the removal efficiency of the concentration of 4-nitrophenols input applied to the reactors studied in the study was observed, so that by increasing the concentration of 4-nitrophenol input from 252 to 1610 mg/l in the remaining time of 24 And 48 hours of pollutant removal efficiency decreased by 43% and 40%, respectively.

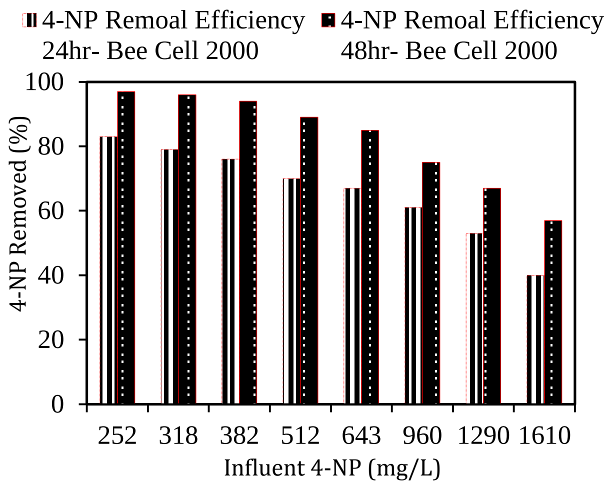

Fig. 2. Changes in removal efficiency of 4-nitrophenol during retention time and different concentrations of 4-nitrophenol input (50% filling percentage)

3.3. Investigation of the effect of shock on the efficiency of research bioreactors

In order to investigate the effect of organic charge shock on the efficiency of the research bioreactor, the amount of COD input to the reactor was increased by 2000 mg/l after reaching an efficiency of less than 50% in the main tests, so that in the reactor containing acne Bee Cell 2000, The input feed was increased from COD equivalent to 3000 mg/L to 5000 mg/L. The results of experiments investigating the effect of shock on the reactor containing Bee Cell 2000 acne are presented in Fig. 3. In this reactor, shock was initially severely reduced, and a sharp decrease in efficiency was observed, removing up to 3% during the 24h after the contaminant loading.

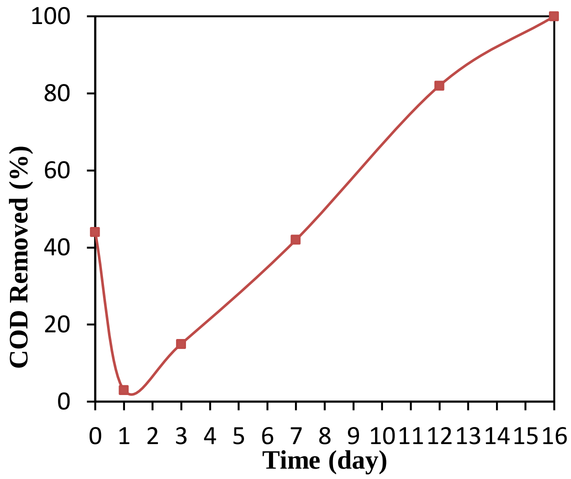

Fig. 3. Contaminant removal efficiency in a reactor containing Bee Cell 2000 media after shock (50% filling percentage, input COD equal to 5000 mg/L)

4. Conclusions

Regarding the behavior of MBBR systems during increasing load in the adaptation stage, it can be concluded that at each stage of increasing the load, after repeated loading in the final stage loads, slight changes in the removal of 4-nitrophenol and COD were observed. The cause of this behavior can be attributed to the greater compatibility of microorganisms with pollutants.

To evaluate the effect of time, sampling was performed at 8, 12, 24 and 48 hours. The results showed that increasing the retention time increased the removal efficiency.

4-nitrophenol and COD. For example, in a COD of 1000 mg/L, in a reactor containing Bee Cell 2000, the COD removal efficiencies of 35, 53, 68, and 86 were 8, 12, 24, and 48, respectively.

To investigate the effect of reducing the percentage of media filling, the percentage of media filling was reduced from 70% to 50% and from 50% to 30% in two stages. The results related to COD removal efficiency showed that by reducing the filling percentage from 70 to 50%, the removal efficiency is less than in the case where the filling percentage decreases from 50 to 30%. The reason for this result can be attributed to the fact that at 70% fullness, the number of media was much higher, so that some media were stationary in the reactor and the rest of the media were less mobile than the media. They had 50% filling. Therefore, by reducing the filling ratio from 70 to 50%, in practice, the static media left the reactor and more space of the reactor was provided to the remaining media for circulation. However, by reducing the filling ratio from 50 to 30%, despite the improvement of media mobility, in fact, part of the moving media was removed from the reactor, and therefore this change led to a reduction in pollutant removal efficiency. Therefore, the optimal filling percentage according to the mentioned contents for the reactor is 50%.

The results of experiments on the effect of suspended microorganisms in MBBR systems with an initial COD of 1000 mg/L indicate the ineffectiveness of suspended microorganisms.

Based on the kinetic studies performed, the modified Stover-Kincannon model was the best model for the reactor.

Studies and results of reactor shock tests have shown that the reactor has an acceptable ability to withstand organic shock.

5. References

Din MI, Khalid R, Hussain Z, Hussain T, Mujahid A, Najeeb J, Izhar F, “Nanocatalytic assemblies for catalytic reduction of nitrophenols: a critical review”, Critical reviews in Analytical Chemistry, 2020, 50 (4), 322-338. https://doi.org/10.1080/10408347.2019.1637241.

Ghaderi M, Tamadoni A, Mahdizadeh A, “introducing an applied reactor for treatment of wastewater containing propylene glycol”, SN Applied Sciences, 2019, 1 (12), 1-14. https://doi.org/10.1007/s42452-019-1638-2.

Ghaderi M, Asadi P, Kouhirostamkolaei M, “Applying response surface methodology on the results of serial sequencing batch moving bed reactor”, SN Applied Sciences, 2020, 2 (1), 1-12. https://doi.org/10.1007/s42452-019-1894-1.

Ma YS, Huang ST, Lin JG, “Degradation of 4-nitrophenol using the Fenton process”, Water Science and Technology, 2000, 42 (3-4), 155-160. https://doi.org/10.2166/wst.2000.0373.