Retraction

Retraction: Reduction in hydraulic conductivity and organic contaminants through biofilm formation on porous media
(IOP Conf. Ser.: Mater. Sci. Eng. 1145 012002)

Published 23 February 2022

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IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

Retraction published: 23 February 2022

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Reduction in hydraulic conductivity and organic contaminants through biofilm formation on porous media

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Abstract. The creation of municipal solid waste produces serious ecological and community health problem throughout the world, particularly in emerging countries. Undeveloped scrapyards are the eldest and most communal method of solid waste disposal. If this is not properly managed, the migration of leachate from dump yards or landfills and the discharge of pollutants creates subsurface water pollution. Among different pollution measures, biofilm accumulation is the major choice. These studies indicate that biological barriers may be a promising technology to suppress pollutant plumes in the field. The present research focused on, the theory of biofilm aggregation in sand columns has been further to estimate the hydraulic conductivity of synthetic leachate and changes in organic pollutant concentration. Two different column research combinations were completed by using synthetic leachate as substrate solution. One column is used as a blank, and the other column is corrected with a mixed microbial culture separated from the leachate. The layered experimental mode using two different sizes of sand (0.3 mm and 0.6 mm) is used for column packing. The tower continuously supplies synthetic leachate for 50 days. Compared with the layered sand column, the hydraulic conductivity of the layered sand microbial column has the largest decrease, which is 88.42%. The analysis of organic pollutants in wastewater leachate also clearly shows that, compared with natural and synthetic liners used to control the migration of leachate in the underground environment, layered sand modified with microorganisms has appropriate remedial measures.

1. Introduction
Dumping municipal solid waste in uncontrolled landfill creates major impact on the atmosphere and human health [1]. Continuously increasing people’s awareness to protect groundwater sources from pollutants generated by garbage dumps has led to the design of enclosures with good isolation, resulting in the use of a mixture of natural clay and bentonite with lower permeability [2].

Geosynthetic clay lining (GCL) is gradually used as a component of composite lining with geomembrane (GM) in landfill barrier system because lack of impermeable natural clay lining [3]. The main advantage of GCL is its limited thickness, which can well comply with the differential settlement of the primary ground or waste, is simple to set up and little in cost. The GCL will lead to: (1) susceptibility to mechanical accidents; (2) partial adsorption capability; and (3) if the underlying attenuating mineral layer is not provided, the expected diffusion is significant increase. [4] The liberation of heat in the landfill generates a thermal gradient through the composite lining, thereby
maintaining the possibility of net infiltration of potential moisture from the warmer lining. As a outcome, there is a prospective for drying, which may damage the long-term performance of GCL [5]. The various methods given as uneconomical, also it leads to the failure level.

The accretion of permeate in cohesionless layers reduces the hydraulic conductivity and the concentration of organic pollutants in the leachate. Excavate aquifer materials and replace them with bioaccumulated culture as levelled treatment layer and standing treatment wall to eliminate pollutants in the in-situ conversion process [6]. In consideration of results, risks and costs of various contaminated groundwater remediation measures, biofilm deposition is the first choice [7]. The accumulation of biofilm in porous media is because of the adsorption, desorption, surface growth, separation and filtration of microbial cells. The growth of microorganisms on the ground leads to a decrease in hydraulic conductivity, leading to groundwater replenishment, prevention of groundwater pollution, land pollution, recovery of lubricants and on-site preservation methods using biobarrier [8].

In this study, the effect of layered sand columns on biofilm accumulation is described as: (1) decrease in the permeability using biobarrier formation and (2) the degradation of organic pollutants expressed in COD.

2. Materials and Methods
The cohesionless material was identified and taken from the stream. The same material is sieved, and the part remaining on 0.6mm and 0.3mm is rinsed with deionized water, dried under normal heat (27°C), and kept in a purified container. Biomass culture were developed using the leachate sample collected from the open dump yard.

Food medium for the biomass consists of 10 g of protein (P), 2 g of beef extract, 1 g of yeast extract and 5 g of sodium chloride in 1 L of distilled water and maintain the pH at 7±0.2 by adding HCl (0.1N) or NaOH (0.1N) [9]. Using autoclave, the nutrient medium and sand are sterilized at 15 kPa and 121°C for 20 minutes. Percolate (10 ml) and nutrient medium (100 ml) was mixed and incubated at 37°C for 48 hours. Synthetic leachate was used as substrate solution it contains Acidic acid, Propionic acid and Butyric acid with various salts and trace metal solutions. Transplant the mixed bacterial culture (40 ml) into synthetic percolate (400 ml) containing 14,000 mg/L COD. Then the incubated aerobically at 27°C for 7 days on a 125-RPM orbital shaker [10]. The experimental column was filled with developed microbial biomass solution.

The changes in permeability and reduction of carbon-based pollutants because of biofilm accumulation were studied using column. Two identical glass columns with a diameter (2.5 cm and length of 35 cm) are used (Figure 1).

![Figure 1. Schematic Representation of Experimental Setup](image-url)
The first column is filled with a layered sand layer and modified by microorganisms (SSMM), top layer (0-15 cm) consist of 100 grams of 0.6 mm sand and bottom layer (15-30 cm) contains 110 grams of 0.3 mm of sand with biomass. The second tower is filled with a layered sand medium layer (SSM), ie no biomass is added. The inoculated sand column was incubated for 24 hours under no-flow conditions to encourage bacterial affection to the sand. Set up a peristaltic pump to dispense a constant flow of 1 ml/min synthetic percolate on the two columns for approximately 45 days. Using the constant head method, Darcy's law is used to calculate the alteration in hydraulic conductivity over time.

3. Results and Discussions

3.1 Effects of Biofilm accumulation on Hydraulic Conductivity

Throughout the experiment, each column maintained a constant pressure head, and the volume was measured at 24-hour intervals. From Figure 2, the following discussion was made: the initial hydraulic conductivity of the column is 2.03×10^-2 cm/s. After 45 days, the hydraulic conductivity (cm/s) in the column decreased to 1.09×10^-2 (SSM) and 2.35×10^-3 (SSMM). The observed hydraulic conductivity in the microbial column was almost similar to the initial value of the first 15 days, and then began to decrease slightly because of the precipitation of the permeated synthetic leachate [11], [12] and [13] reported similar results.

During the study period, it was observed that the hydraulic conductivity of the layered coarse and fine sand medium with microbial column (SCFSMM) was reduced by 88.42%. In the first 6 days of experimental operation, the hydraulic conductivity decreased by 36%. This is due to the rapid growth of microorganisms in the column. On the 25th day, the drop in hydraulic conductivity further increased to 80%. From the 27th day, to the end of the experimental operation (the 45th day) it was maintained in stable state. From the results of the experimental column, compared with other blank stratified columns SSM, the hydraulic conductivity of SSMM column has a greater decline.

![Figure 2. Changes in Hydraulic Conductivity as Function of Time](image-url)

![Figure 3. Changes in COD as Function of Time](image-url)

3.2 Effects of Biofilm accumulation on COD Removal

The substrate concentration curve is predictable by measuring the soluble COD (SCOD) concentration in the leachate sample extracted from the outlet of each column. During the experimental operation, a
synthetic leachate with an initial COD concentration (14000 mg/l) was provided. From Figure 3, a slight decrease in SCOD (2%) was observed in the blank column SSM. In the SSMM column, a 5% reduction in SCOD was observed in the first 10 days of surgery. This is due to the fact that there is little attachment of microorganisms to the sandy medium inside the column. From the 21st day onwards, it entered a steady state, and the decrease in SCOD concentration was 41% at the maximum.

Over time, COD is consumed faster, which means that with the continuous supply of nutrients and electron acceptors, the growth of microorganisms is continuous throughout the depth of the column [8, 14 and 15]. By comparing the results of the two columns, the SCOD concentration in the percolate sample collected from the outlet of the SSMM column was greatly reduced.

4. Conclusion
This research reveals the following conclusions:
1. Through experimental column research, the hydraulic conductivity of the microbial inoculation column SSMM is reduced by 88.46%. Similarly, the SCOD in the SSMM column was reduced by 41%. The less SCOD reduction in the stratified tower is due to the less increase in biomass attached to the coarse sand media.
2. From the overall results of the experimental study, it was found that biological barrier formed by the microbial modified layered sand media (SSMM) provides an appropriate remedy for reducing the hydraulic conductivity and organic pollutants in the leachate.

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