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Sonali R Dhokpande
Sant Gadge baba Amravati University, Amravati, Maharashtra, India

Dr. Jayant P Kaware
Sant Gadge baba Amravati University, Amravati, Maharashtra, India

Correspondence
Sonali R Dhokpande
Sant Gadge baba Amravati University, Amravati, Maharashtra, India

Tricking flow nickel treatment for wastewater: An investigation on selective operating parameters

Sonali R Dhokpande and Dr. Jayant P Kaware

Abstract
Tricking filters works on the principle of attached growth processes. The biological slime layer is grown on the support and effluent is passed over it. Generally it is used for removal of organic matter. The tricking filters have been used successfully by many researchers for removal of variety of pollutants due to its simplicity, and less space requirement. In current investigation the trickle bed was prepared on stone support by growing biological layer. The studies were carried out to study effect of flow rate, initial concentration; slime layer preparation time and fruit peel concentration. It was observed that the time required to reach exhaustion concentration decreases with flow rate, initial concentration and preparation time. There exits optimum value beyond which the increase in the slime layer preparation time and fruit peel concentration doesn't have significant impact on removal.

Keywords: heavy metal, suspended growth, attached growth, slime layer preparation time, fruit peel concentration

Introduction
Wastewater treatment by biological methods is widely practiced treatment technique. Suspended and attached growth treatment methods are adopted according to requirement and loading. Activated sludge and tricking beds are used for these treatments respectively. Also these treatment techniques are classified as aerobic and anaerobic. Aerobic attached growth biological treatment processes are usually used to remove organic matter found in wastewater. They are also used to achieve nitrification. The attached growth processes include the Trickling filter, the roughing filter, rotating biological contact-or, and fixed film nitrification reactor. The limitation of contact filter included a relatively high incidence of clogging, the log rest period required, and the relatively low loading that could be used.

Literature Review
Many investigators have used domestic waste materials such as fruit peel waste, tea waste, maize cobs et. For removal of nickel from wastewater. Abbasi *et.al*. worked on adsorptive removal of CO^{2+} and Ni^{2+} by peels of banana from aqueous solution [1]. They studied the effect of operating parameters like pH, adsorbent dose, time and concentration on cobalt and nickel removal. It was observed that the optimum values for pH and adsorbent dose were observed to be 5.5, 3 grams/l respectively. Their studies also indicated that adsorption capacity of banana peel increased with increasing the equilibrium metal ion concentration. Muthusamy et.al used Maize cobs as an adsorbent for nickel removal [2]. They studied effect of initial concentration, adsorbent dosage, contact time and agitation speed on nickel removal. In their studies, they observed that an increase in the biosorption percentage with dosage of biosorbent upto certain level. It was followed by decreasing trend. Optimum contact time for biosorption was found to be 90 minutes. Seshadri *et.al* carried out an investigation with Citric acid modified annona squamosa (custard apple) bark powder for nickel [3]. Maximum biosorption efficiency of nickel (II) ion onto biosorbent was found to be 98.96% at the dose of 0.4 g for contact time for 10 minutes. Pouteria sapota seeds carbon was used for nickel removal by Rani *et. al*. [4]. They treated it with sulphuric acid. Percentage nickel removal for SPSS and CAC were observed 80% and 74% respectively. Tea factory waste was used for nickel removal by Malkoc and Nuhoglu [5]. In their studies it was that the Nickel removal efficiency of 82.4 % at an optimum pH value of 4 has been reported. biosorption process fits the Langmuir isotherm model. Their studies revealed tricking filters are used when space requirement and generation of sludge is major problem in suspended growth operations.

Logan *et.al*. worked on trickling filter based biofilm model [6]. Their studies indicated that first order uptake kinetics and laminar flow in thin films. Diffusion to the biofilm controlled the nickel uptake was observed in their research. Dermou *et. al*. studied a pilot-scale trickling filter for nickel removal [7]. They carried out comparative studies on three contacting models namely batch, continuous and sequential batch reactor (SBR) with recirculation. Study indicated that SBR operation with recirculation was a very effective operating mode. Lopes and Ferreira used recent multiphase models to investigate the hydrodynamic behavior of a Trickle-Bed Reactor (TBR) [8]. They studied hydrodynamic behavior of TBR in terms of pressure drop, liquid holdup and catalyst wetting efficiency. The study indicated that Computational Fluid Dynamics (CFD) model estimates hydrodynamic parameters with reaction conditions with great extent. Based on the volume averaging of the continuity and momentum equations they developed Eulerian k-fluid model. It was concluded that Euleriank-fluid model has shown promising results for flow simulation in packed beds. Chirwa and Smit carried out investigation on simultaneous Cr (vi) reduction and phenol degradation in a trickle bed reactor system [9]. They used a mixed culture isolated from activated sludge from the wastewater used for chromium reduction. It acclimate the bacteria in mixed culture to phenol toxicity and supplied with phenol as a sole carbon source in a trickle bed reactor system. 70 % and 80% removal achieved for chromium and phenol respectively. Gabbiye et.al worked on performance of trickle bed reactor and active carbon in the liquid phase oxidation of phenol [10]. They studied various aspects like the assessment of key engineering aspects such as reactor start-up, gas-liquid flow directions and effects of temperature, pressure, phenol feed concentration and liquid flow rate on activity and stability performance of unsupported active carbon for trickle bed reactor and active carbon catalyst to catalytic wet air oxidation of phenolic pollutants. Their research showed that there was need of some promising options for improvement of catalyst stability. Investigation on textile wastewater decolorization performance using marasmius sp. in immersion and trickling systems was carried out by Hambali *et. al* [11]. They used An Indonesian white rot fungi namely Marasmius sp. grown on palm oil fibers as a base material for a decolorization process. They used pilot plant scale bioreactors to observe the best support configuration and modus operandi. The operation variables were support configurations, i.e. 2 and 3 beds, and modus operandi, i.e. trickling and immersion systems. Their study revealed that the most significant decolorization process occurred after 5 days and 14 days in the trickling system and immersion system, respectively. It was observed that trickling system gives faster rate of decolonization process (5 days) compared to immersion system

Methodology

Locally available fruit peels were used for preparation of trickling bed. Fruit peels cut to smaller size and allowed to form layer on stone support. After sufficient contact period, the stones with biological slime layer were transferred to the tricking column. Then the synthetic nickel solution was passed with required flow rate. The outlet nickel concentration was measured periodically till saturation is attained. For measurement of the nickel concentration, flame absorption spectrophotometry was used. The equipment consist of cylindrical vessel with 30 cm diameter and 60 cm height kept on support as shown in figure 1. The effluent was passed through the bed via distributor by gravity. Experiments were carried out at various values of flow rate, concentration, slime layer preparation time (SLPT) time and fruit peel concentration (FPC). Synthetic nickel solution was prepared by using nickel sulphate.

Results and Discussion

Effect of Flow rate on Nickel Removal

As shown in fig 1, it was observed that with increase in flow rate the time required to reach ultimate concentration decreases. It was also observed that reaching the minimum level after first 10 minutes, there was rapid increase in the flow rate by about 83 percent. For 150 lpm, if we consider break point as time required for reaching 10 percent of initial concentration then the corresponding break point time was 10 minutes. The exhaustion concentration was observed to be 605 mg/l at 90 minutes. For 100 and 50 lpm, the values for the time required for break point and exhaust concentration were 25 and 90 minutes,40 and 120 minutes respectively. This can be attributed to Rapid availability of metal ion.

Effect of Initial Concentration on Nickel Removal

As shown in fig 2, it was observed that with increase in concentration the time required to reach ultimate concentration decreases. It was also observed that after first 10 minutes, there was rapid removal of nickel by about 94.8 percent for 1000 mg/l. If we consider break point as time required for reaching 10 percent of initial concentration then the corresponding break point time was 15 minutes. The exhaustion concentration was observed to be 605 mg/l at 90 minutes. For 500 and 250 mg/l, the values for the time required for exhaust concentration were 240 and 300 minutes respectively. The difference in the driving force is the reason for rapid saturation at higher concentration.

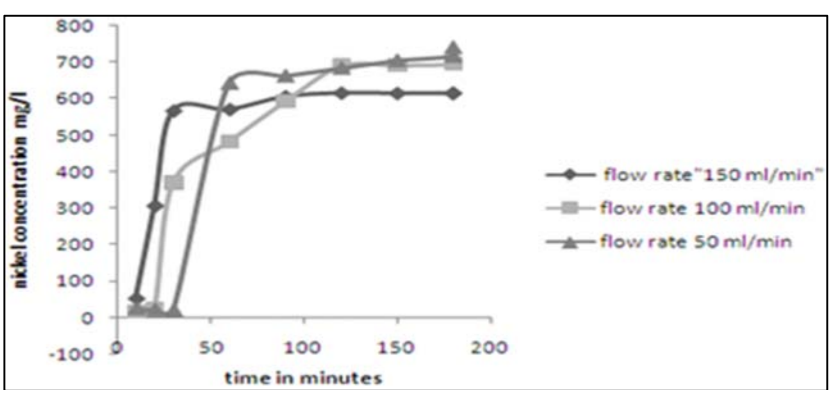

Fig 1: Effect of Flow Rate on nickel Removal

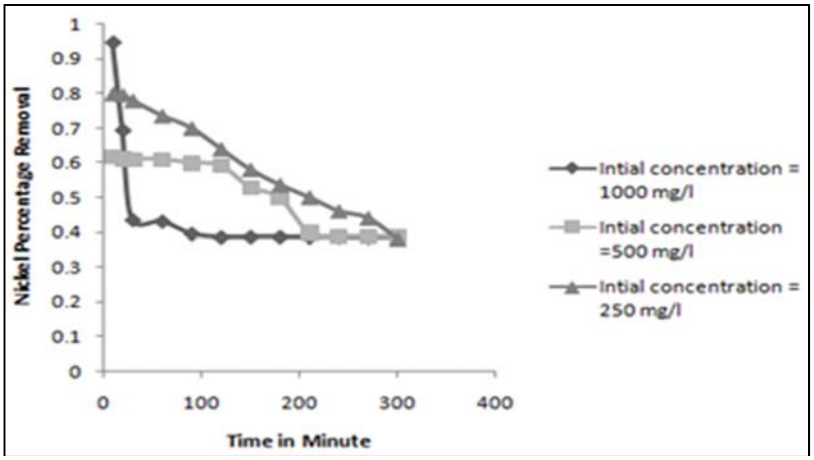

Fig 2: Effect of Initial Concentration on Nickel Removal

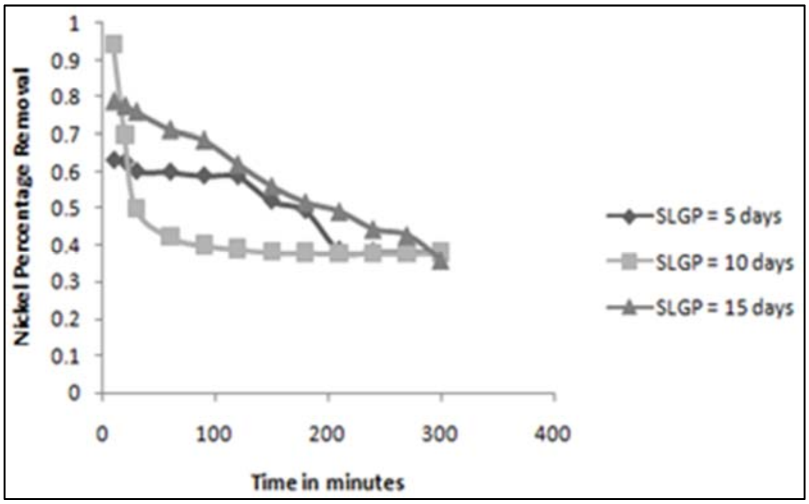

Fig 3: Effect of SLPT on Nickel Removal

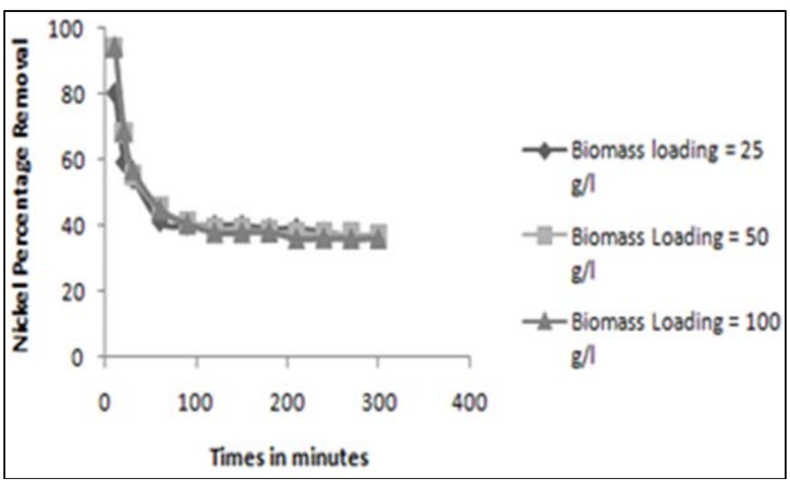

Fig 4: Effect of FPC on Nickel Removal

Effect of Slime layer Preparation Time on Nickel Removal

As shown in fig 3, it was observed that with increase in slime layer preparation time (SLPT) time required to reach ultimate concentration decreases with increase in SLPT from 5 days to 10 days. It was also observed that further increase in SLPT doesn't have any considerable effect on biosorption. There was rapid removal of nickel by about 94.3 percent for 10 days SLPT. The time required to reach the exhaust concentration decreased from 210 minutes to 120 minutes for increase in SLPT from 5 to 10 days. For further increase i. e. for 15 hrs SLPT, the corresponding time was 180 minutes. So 10 days of SLPT was considered as optimum.

Effect of Fruit Peel Concentration on Nickel Removal

As shown in fig 4, it was observed that with increase in fruit peel concentration (FPC) time required to reach ultimate concentration decreases with increase in fruit peel concentration from 25 g/l to 100g/l. There was rapid removal of nickel by about 94.3 percent for 50 and 100 g/l FPC. The optimum FPC was 50 g/l as further increase in FPC does not have significant rise in removal.

Conclusion

In the current work, the studies were carried out to study effect of flow rate, initial concentration; slime layer preparation time and fruit peel concentration. Studies indicated that with increase in flow rate and initial concentration the time required to reach ultimate concentration decreases. Rapid availability of ions and the difference in the driving force is the reason for rapid saturation at higher concentration. The time required to reach the exhaust concentration decreased from 210 minutes to 120 minutes for increase in SLPT from 5 to 10 days. The time required to reach the exhaust concentration decreased from 210 minutes to 120 minutes for increase in SLPT from 5 to 10 days.

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