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Kinetics of manganese removal from bore well water using Katalox Light, Birm and ISR

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Abstract

Groundwater scarcity and quality degradation has been a pertinent issue in Kathmandu Valley (KV). The high concentration of Manganese in the groundwater is the major issue in the drinking water quality. This research work presents the removal Manganese through comparative study between Katalox light filtration model (KLFM) and Rapid sand filtration model (RSFM) at three different flow rates. Gravel, Katalox light, Burgess Iron Removal Method (BIRM), Iron Specific Resin (ISR) and sand are commonly used filter media for KLFM and RSFM respectively. KLFM filtration is physio-catalytic adsorption purification process of high removal capacity of Manganese at higher pH. Two identical filter columns packed with Katalox light 1.24mm size (depth 96.52cm), ISR 0.56mm size (depth 5.1cm), BIRM 1.23mm size (depth 38.1cm) and sand 0.57mm size (depth 60cm) were used and operated at three discharges viz., 0.018L/s, 0.020L/s and 0.022 L/s at Manohara-Besi Water Supply Committee located in Changunarayan Nagarpalika, Bhaktapur and detailed study was conducted. As the influent raw Manganese concentration varied up to of 0.672mg/L, the effluent Mn concentration was found to be 0.024mg/L, 0.026mg/L and 0.044mg/L in KLFM and 0.542mg/L, 0.534mg/L and 0.628mg/L in RSFM at 0.018L/s, 0.020L/s and 0.022L/s respectively. The average Manganese removed at 0.018L/s, 0.020L/s and 0.022L/s were found to be 96.000%, 95.785% and 93.388% in KLFM and 10.500%, 9.507%, and 6.612% in RSFM of influent average Manganese concentration respectively. The Manganese removal was found to be more effective at flow rate of 0.018L/s. KLFM and RSFM Filters were backwashed with backwashing velocity of 24 m/h with periodic 10-15minutes and 36m/h within 3 days respectively, when the terminal head loss of 215.7cm and 219cm was obtained and both filters were run in parallel for 1.5 hours daily. It was concluded that the KLFM media could be a good media for the reduction of Manganese concentration.

1. Introduction

Manganese is commonly found together with iron in groundwater and is normally not considered to be of health concern. However, there are several problems that can occur if too much manganese is present in the water, such as generating a metallic taste and colored water, staining of laundry and plumbing fixtures, formation of deposits in the distribution system, and plumbing, and interference with the disinfection process. Manganese is found in widely varying concentrations in surface and groundwater sources. Aerobic or oxidized environments often yield soluble Manganese concentrations of less than 0.05 mg/L [1] or the maximum concentration within the range of 0.2ppm [2] with the predominant species being MnOx(s) precipitates. However, soluble manganese concentrations can exceed 1.0 mg/L in the reduced environment that typically exists in groundwater and reservoir hypolimnion. The concern over elevated Manganese concentration in finished water supplies is based on aesthetic issues associated with water and plumbing fixture discoloration. To help to minimize these problems, many states of North America have implemented a secondary maximum contaminant level (SMCL) of 0.05 mg/L for Manganese [1]. Manganese is an essential element for humans and other animals and occurs naturally in many food sources. The most important oxidative states for the environment and biology are Mn2+, Mn4+, and Mn7+. Manganese is

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naturally occurring in many surface water and groundwater sources, particularly in anaerobic or low oxidation conditions, and this is the most important source for drinking water. However, there are several significant potential confounding factors in these studies, and several other studies have failed to observe adverse effects following exposure through drinking water. Further, rodents are of limited value in assessing the neurobehavioral effects (e.g., tremor, gait disorders) seen in primates, which are often preceded or accompanied by psychological symptoms (e.g., irritability, emotional lability), which are not apparent in rodents. The only primate study is of limited use in a quantitative risk assessment because only one dose group was studied in a small number of animals and the manganese content in the basal diet was not provided.

2. Objectives

The main objective of this study is to develop of kinetics of Manganese removal of Katalox light, BIRM and Iron specific resin (ISR) as filter media over conventional media for removing selected parameters guiding drinking water quality while operating under similar conditions of raw water quality and environmental conditions. The specific objective can be listed out as follows:

i To determine the Manganese removal efficiency of Katalox light and rapid sand filtration system.

ii To compare the Manganese removal as per depth of filtration media.

iii To determine the effect of discharge on removal of manganese.

3. Materials and methods

The study was started using two filter columns made of fiberglass. One of the filter columns was filled with the Katalox light, BIRM, and ISR, and another was filled with sand as filter media over the supporting material gravel. The gradual adaption of the actual Manganese containing boring water was studied on the KLFM and RSFM.

3.1. Experimental setup

The study area is at Manohara-Besi Water Supply Committee located in Changunarayan Nagarpalika, Bhaktapur and lies at 27° 42’ 29.97" N latitude and 85° 24’ 39.29" E longitude. The reactor was constructed using a fiber glass of $(11 \times 11 \times 290)$ cm^3 of internal dimension. Gravel 63.5cm, Katalox Light 96.52cm, BRIM 38.1cm and ISR 5.1cm media were filled in KLFM reactor whereas 60cm gravel and 60cm sand media were filled in RSFM flow reactor. The deep boring water by means of vertical submersible pump was pumped and used as influent water to the reactors in the down flow mode. The schematic flow diagram is presented in Figure 1. As the raw water containing dissolved Manganese was passed through both the models, the transport, oxidation, attachment and precipitation followed with filtration mechanisms was occurred in RSFM and KLFM. The influent Mn concentration was naturally varying and dependent on field condition, resulting in varied influent Mn concentration.

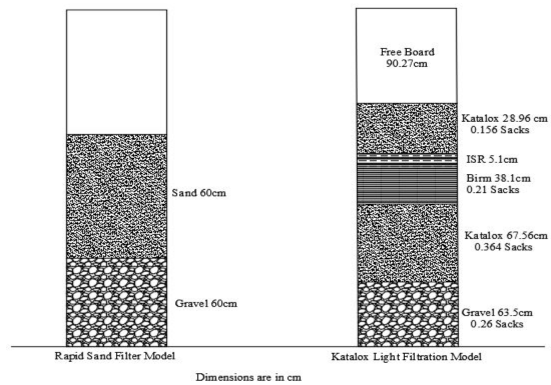

Figure 1: Schematic diagram of media arrangement in down flow KLFM and RSFM reactor.

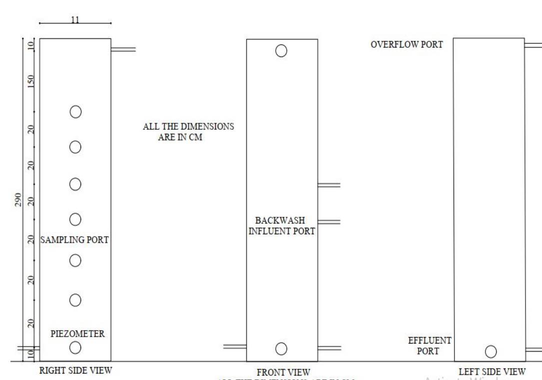

Figure 2: Detail drawing of Filter Column

3.2. Kinetics of manganese removal in filtration

The study was mostly focused on the kinetics of Manganese removal in the KLFM and RSFM system. The kinetics of Manganese removal was observed during different flow rates. Particular influent Manganese concentration was checked at a flow rate of 0.018L/s, 0.020L/s, and 0.022L/s to find the mechanism of Manganese removal in the KLFM and RSFM System. The Manganese removal efficiency is calculated based on measured influent and effluent Manganese concentration.

3.3. Analytical methods

For the sample analysis, the Manganese concentration were measured by Persulfate and Spectrophotometry at absorbance of 525nm.

4. Result and discussion

The Manganese removal capacity of the KLFM and RSFM filtration system is observed by measuring influent and effluent Manganese concentration at discharges 0.018 L/s, 0.020 L/s, and 0.022L/s at the same 1.5hrs filter run time, at different influent Manganese concentration ranges from 0.550 mg/L to 0.800 mg/L. The removal capacity decreases with the increase of overflow rate or discharge.

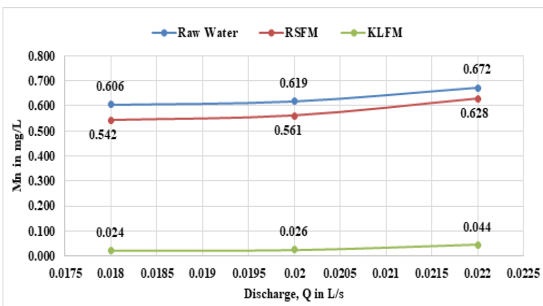

Figure 3: Manganese concentration at three different sets of discharge

In the first, second, and third discharge, the Manganese concentration produced by RSFM was above 0.2mg/L as the lower limit and KLFM was below 0.2mg/L as the lower limit [2]. There was much difference in Manganese concentration produced for both the media. However, the quality of effluent was relatively better by KLFM than RSFM. The Manganese concentration produced by RSFM was greater than 0.2mg/L which is not safe for human consumption. [2].

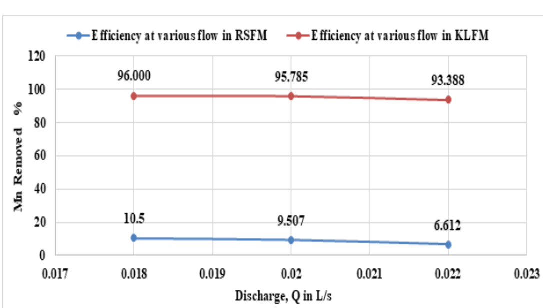

Figure 4: Average Mn Removal efficiency at various discharge

However, in terms of removal efficiency, KLFM media show high Manganese removal efficiency than that of RSFM media. In all three sets of discharge, the KLFM showed better average Manganese removal efficiency as compared to RSFM 0.2mg/L as a lower limit [2].

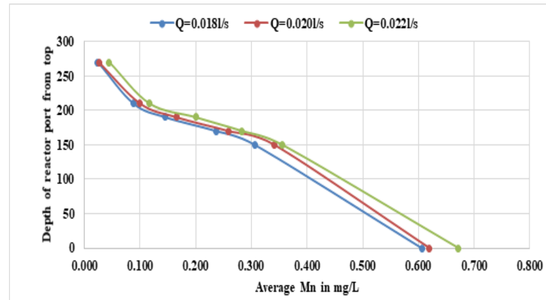

Figure 5: Average Mn Removal efficiency at various discharge

In the first, second, and third discharge, as the depth of port was increased from the overflow port, Manganese concentration produced by KLFM at different depths was decreased gradually below 0.2mg/L as a lower limit [2] as shown in Figure 5 but in a RSFM, Manganese concentration wasn't decreased to an acceptable limit. There was much difference in Manganese concentration produced for both the media. However, the quality of effluent was relatively better by KLFM than sand as per the port depth of the reactor. The Manganese concentration produced by RSFM was greater than 0.2mg/L which is harmful for human consumption. However, in terms of removal efficiency, KLFM media show high Manganese removal efficiency than that of RSFM media as depth variation.

5. Conclusion

This study was aimed to determine the Manganese removal efficiency of KLFM and RSFM in Manohara-Besi Water Supply Committee at various flow rates. From this study, it can be concluded that Manganese removal was less at higher flow rates in comparison to lower flow rates. Finally, it is concluded that actual observed efficiency and Manganese removal mainly depends upon the nature of dissolved minerals in the influent of groundwater. The maximum Manganese removal efficiency in KLFM and RSFM system is obtained as 96.000%, 95.785%, and 93.388% in KLFM and 10.500%, 9.507%, and 6.612% in RSFM at the discharge of: 0.018L/s, 0.020 L/s, and 0.022L/s respectively, not exceeding the NDWQS guidelines in KLFM and exceeding the NDWQS guidelines in RSFM. So, it can be concluded that KLFM media could be good media for the removal of water containing high concentration Manganese.

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References

[1] World Health Organization. Guidelines for Drinking-water Quality: incorporating 1st and 2nd addenda, Vol. 1, Recommendations[R]. Geneva: United Nations, 2008: 397.

[2] Ministry of Physical Planning and Works. National Drinking Water Quality Standards[R]. Kathmandu, Nepal: Government of Nepal, 2062: 1.