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Kinetics of Manganese removal using different proportion of BIRM and Katalox

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Abstract

The researches on the health effect due to manganese consumption through drinking water in human, It was found that long exposure to manganese may cause problems with memory, attention, and motor skills. Infants may develop learning and behavior problems. According to NDWQS the maximum limit of manganese concentration in drinking water must be below 0.2 mg/l. Drinking water with high concentration of manganese can severely stain fixtures and laundry as well as increase turbidity and foul tastes. In some event when the concentration is very high it can cause a decrease in consumer confidence in the quality of water provided to their taps. Currently, there is no other treatment method that can remove manganese efficient and economical way as the oxide coated media filtration. The removal of soluble manganese in sub surface water by catalytic oxidation while passing through the manganese dioxide coated media is carried out in various drinking water schemes, although the kinetics of removal of manganese using BIRM and katalox light has not been investigated. Proportionate depth of BIRM and katalox light for effective removal of manganese was determine using three pilot scale non pressures down flow reactor column. The water with constant discharge of 0.1 lps passing through the layer of BIRM and katalox with effective size 1.24 mm and 1.23mm respectively, the efficiency of removal for three combination of media from higher to lower depth was found to be 100%, 98.46% and 45.68% respectively. But the filter run time before the clogging and overflowing of reactor was found out to be 180 min 270 min and 405 min from higher to lower depth respectively.

Keywords

BIRM, Katalox Light, Manganese, Catalytic Oxidation, Manganese dioxide

1. Introduction

The removal of soluble manganese (Mn) in water treatment facilities is often necessary to minimize the potential for water discoloration and complaints by consumers. While aesthetic (discoloration) issues have been the primary motivation historically for practicing Mn removal research, studies have documented potential health effects due to elevated Mn in drinking water [1]. Such concerns have prompted Health Canada (2016) to propose a legally enforceable, health-based drinking water standard of 0.10 mg/L. The US Environmental Protection Agency likewise added Mn to its most recent promulgation of the EPA Critical Contaminants List (CCL4). A common treatment process for soluble Mn+2 removals is the natural greensand effect (NGE) during granular media filtration, which has proven to be very effective over a wide range of raw water conditions [2];[3];[4] [5];[6]. During the NGE process, soluble Mn+2 ions are adsorbed to manganese oxide-coated MnOx media. The adsorbed Mn+2 are then oxidized by chlorine, forming more MnOx to become part of the coating structure. MnOx coating level is increased over time through a continuous process of Mn+2adsorption and oxidation, and the resulting media is available for the adsorption of additional soluble Mn+2 ions [7]. Studies have shown that the adsorptive uptake process for soluble Mn+2 on MnOx coated media depends on: (1) the presence of a free chlorine residual in the filter-applied water, (2) a filter-applied pH of greater than 6.0, and (3) the presence of soluble Mn+2 for adsorptive uptake [6]. While such coatings typically develop naturally over time, researchers have demonstrated means by which MnOx coatings can be deposited on anthracite coal and sand media at significantly faster rates than occur naturally in water treatment situations [7]; [8].

2. Materials and Methods

The study is carried out in three different down flow reactor made up of fiber glass and fabricated with inlet and multiple number of outlet port.The filter media BIRM and Katalox is placed in all three reactor as per the design data given in the table 1 in two different layer supported by equal depth of gravel at the bottom of the column. The efficiency of removal of manganese is calculated by measuring the concentration of the manganese in the outlet water tapped from the port located at the different height of the reactor. The inlet discharge for each combination is maintained constant throughout the experiment and the manganese concentration of the raw water is measured before each run of the filter.The water from the source is pumped and stored in overhead tank and allowed to reactor from the top.filter run time of 45 minutes is maintained during each run and the working head of the reactor at the end of each run time is measured using piezometric pipe connected at the bottom of the reactor.

2.1 Study Area and Experimental Setup

The study is conducted at Manohara-Besi Water Supply Committee located in Changunarayan Municipality, Bhaktapur and lies at 27º 42' 29.97" N latitude and 85º 24' 39.29" E longitude. The reactor was built in factory and fitted in the Manohara-Besi Water Supply system. The cross section of the reactor column is (11x 11) cm2 with height of 294 cm . The different depth of media used for three different combinations is shown in Table 1. The arrangement of the different port with their respective height from the bottom is shown in the Figure 1.

Table 1: Depth of media for different combination

Combination	Media Depth(Cm)	
	Katalox	BIRM
Combination(1)	75	40
Combination(2)	96.5	45
Combination(3)	114	55

2.2 Analytical Methods

The head loss in the reactor after each run of the filter is calculated by measuring the working head and normal water level in the reactor by the pipe connected at the bottom of the reactor. The filter runtime for each run of the filter is measured by using stopwatch, the concentration of manganese in water collected from the inlet and different outlet at the end of the each run is measured in the lab by Spectrophotometric per sulfate method at absorbance of 525nm.

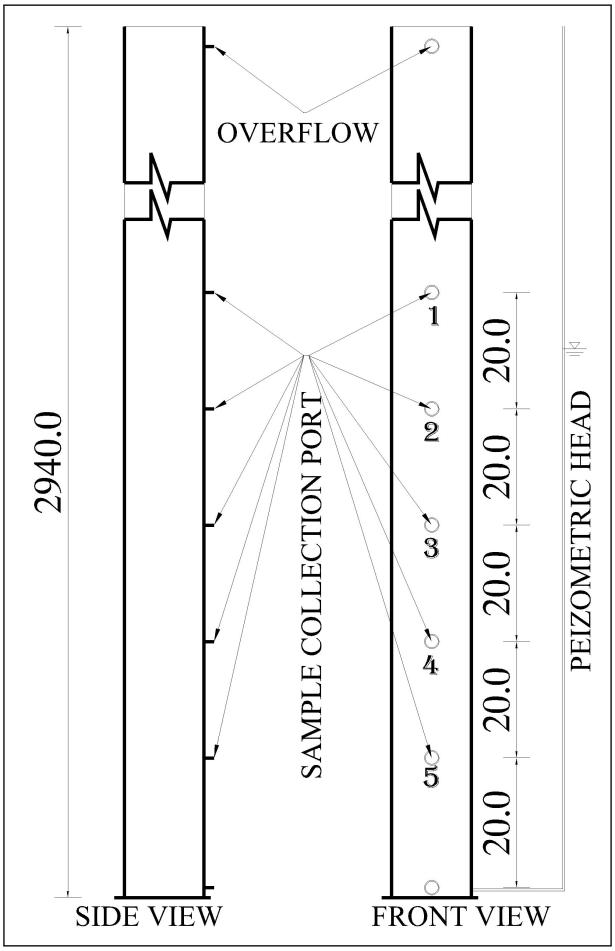

Figure 1: Variation of Mn removal with run time

3. Results and Discussion

The influent and effluent manganese concentration of different combination of the filter media is measured at the end of each run time of 45 minutes with constant discharge of 0.1 lps until overflowing of the inlet water occurs from the overflow port located at the top due to clogging of the filter. The capacity of the removal of manganese for each combination is calculated. The variation of removal capacity at end of each run time for each combination is plotted as show in Figure 1. At the end of breakthrough condition of the filter the average removal efficiency of the filter for combination (1) combination (2) and combination (3) is found to be 51.91%, 93.49% and 100% respectively. Also the efficiency of the removal of soluble manganese from water is found to be in decreasing order with increasing run time of the filter, For combination(1) the removal efficiency is decreased by 12.36% for combination(2) it is found to be decreased by 2.74% on contrary for combination(3) it is found to be remain constant throughout the experiment.

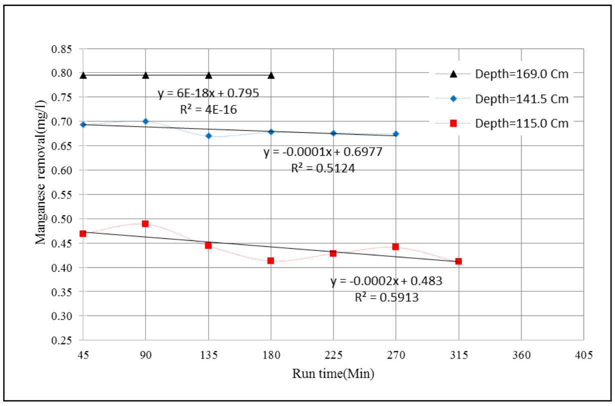

Figure 2: Variation of Mn removal with run time

The initial and development of head loss at constant discharge of 0.1 lps is calculated and plotted in Figure 2 the occurrence of breakthrough condition for each combination is different and as it seems is governed by the depth of the media. For combination (1) combination (2) and combination (3) is found to be 315, 270 and 180 respectively.

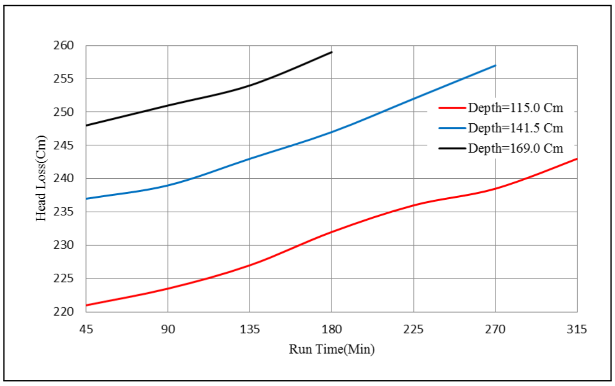

Figure 3: Run time and Head loss

The effluent manganese from the each port for each combination is plotted against their respective depth of the port in Figure 4. According to the NDWQS the acceptable limit of manganese in drinking water is 0.05 mg/l which is only possible when you adopt the higher depth of the media corresponding to combination (2) and combination (3). The media combination (2) can reduce the manganese up to average of 0.051 mg/l and combination (3) can reduced up to 0 mg/l. considering the economical use of the filter media, combination (2) is best combination of media and which will be enough to get the outlet water safe for drinking as per the regulation given by the NDWQS.

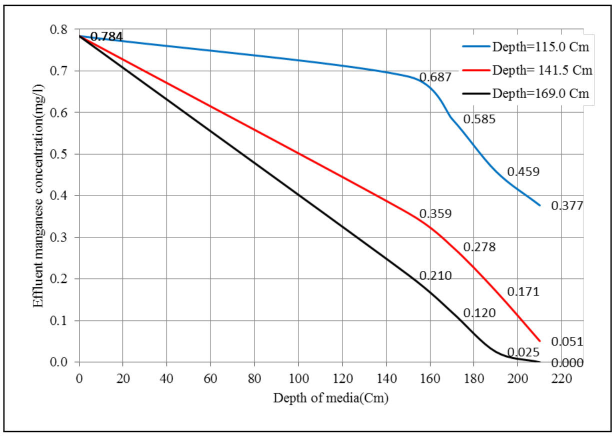

Figure 4: Depth and corresponding effluent Mn

4. Conclusions

The objective of this study is to determine the change in efficiency of removal of soluble manganese by the use of manganese coated media. Among the three adopted depth of the media (115.0, 141.5 and 169.0 Cm) the depth corresponding to 66.53 inch is found to be best for removal of the manganese, But considering the economic use of media and SMCL of manganese concentration in drinking water 53.00 inch of media is found to be sufficient. Efficiency of removal is found to go up to 100% for runtime of 180 minute when the depth of media 169.0 Cm, 93.49% for runtime of 270 minute when depth of media is 141.5 Cm and 51.91% for runtime of 315 minute can be achieved even if the depth of media is reduced to 115.0 Cm. The ability of the media to remove the manganese is calculated for the give discharge and run time of each combination is found to be 58.63 mg/kg for combination (1), 72.84 mg/kg for combination (2) and reduced to 43.60 mg/kg for combination (3).

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References

[1] X Liu. Water manganese exposure and children's intellectual function in araihazar. 2005.

[2] AE Griffin. Significance and removal of manganese in water supplies. 1960.

[3] S C; Hungate R Knocke, W R; Occiano. *Removal of Soluble Manganese by Oxide-Coated Filter Media: Sorption Rate and Removal Mechanism Issue*. Jour. AWWA 83(8), 1991.

[4] D; Knocke W R Coffey, B; Gallagher. Modeling soluble manganese removal by oxide-coated media. 1993.

[5] Y H; Chen J C; Chang C Y Hu, P Y; Hsieh. Adsorption of divalent manganese ion on manganese-coated sand. 2004.

[6] S; Friedman M J; Hill A Brandhuber, P; Craig. Legacy of manganese accumulation in water system. 2015.

[7] W R; Gallagher D; Little J Merkle, P B; Knocke. Dynamic model for soluble mn(ii) removal by oxide-coated filter media. 1997b.

[8] A; Larsen G S; Mai Y; Tobiason John E. Bazilio, Arianne; Kaminski. Full-scale implementation of second-stage contactors for manganese removal. 2016.