



Utilizing Steel Slag in the Removal of Suspended Solids from Dewatered Construction Water

Alaa Al Hawari

a.hawari@qu.edu.qa

Department of Civil and Architectural Engineering, Qatar University, Doha, Qatar

Abdelrahman Tariq

aa083874@qu.edu.qa

Department of Civil and Architectural Engineering, Qatar University, Doha, Qatar

Ahmed T. Yasir

ay1107095@qu.edu.qa

Department of Civil and Architectural Engineering, Qatar University, Doha, Qatar

Mohamed A. Ayari

arslana@qu.edu.qa

Center for Excellence in Teaching and Learning, Qatar University, Doha, Qatar

ABSTRACT

Construction dewatering is an operation used to remove shallow groundwater that infiltrates construction sites. After recovering this water from the construction sites, the water is either discharged to the sea, injected in deep groundwater aquifers, or treated and reused in some other applications. However, municipal and industrial application of this water is unfeasible due to its poor quality. Thus, in this study, dewatered construction water is being treated utilizing waste steel slag in order to improve the quality of the water. The pH of the dewatered construction water used for this study was 7.59 and the average diameter of steel slag used was 425 nm. For coagulation, the impact of the mass of steel slag and the contact time on the quality of dewatered construction water were studied. By using 5gm/L of steel slag, more than 85% of the total suspended solids and turbidity were removed within 30 minutes.

Keywords: Coagulation; Steel slag; Dewatered construction water; Total suspended solids

1 INTRODUCTION

Deep excavation for construction purposes often results in water seepage from underground reservoirs, especially if the water table is high (Calin, 2017). This water might delay the construction process and damage the infrastructure around the construction site (Serag, 2008). The dewatering process of the construction sites can be done by pumping methods or exclusion methods (Somerville, 2008). Once dewatered, this construction water is generally discharged to the sea (Tchobanoglous, 2001). However, this dewatered construction water has low salinity, low concentration of heavy metals and low concentration of total suspended solid (Hawari, 2018). Thus, this water can be reclaimed by low cost treatment process.

Hawari et al. (2018) treated dewatered construction water using a settling tank and a multimedia sand filter (Hawari, 2018). The dewatered construction water had an initial turbidity of 350 NTU. After 1 hour of settling time, the turbidity reduced to 26 NTU. And

by filtering the dewatered construction water using multimedia sand filter, the turbidity was reduced to 24 NTU (Hawari, 2018). Both technologies showed similar turbidity removal efficiency. The efficiency of the settling process can be improved by adding coagulants. Addition of coagulants would neutralize the surface charge of the colloids and improve coalescence in the water. This will help in forming large flocks of colloids which will settle faster. However, using commercial coagulants will reduce the cost effectiveness of the treatment process. Thus, in this paper the feasibility of using steel slag as a coagulant for the treatment of dewatering construction water was investigated.

Steel slag is a by-product of steel manufacturing industry. Limestone is used as a melting point reducing agent in order to remove the impurities in the iron ore which get deposited as steel slag (Dhoble, 2018). Steel slag is usually generated in large quantities and its disposal poses a significant burden on steel factories (Dhoble, 2018). This waste by-product possesses a porous structure with a high surface area and contains oxides such as $\text{FeO-Fe}_2\text{O}_3\text{-SiO}_2\text{-CaO-Al}_2\text{O}_3$. These oxides show characteristics that are similar to coagulants. They have high adsorption capacity and have been used effectively in many studies to remove ammonia, nitrogen, phosphorous and metals from water through adsorption and precipitation (Shilton, 2006; Xiong, 2008; Yi, 2012; Liu, Yuan, 2011). Yin et al. removed 90% of COD from non-degradable organic wastewater using steel slag as a catalyst in an oxidative degradation process (Yin, 2016). Feng et al. used steel slag as an adsorbent to treat acid mine wastewater (Feng, 2004). Since, the density of steel slag is between 3.3 and 3.6 g/cm^3 it can be easily separated from water by gravity settling (Yi, 2012).

Thus, in this study, a coagulation process using steel slag as coagulant is being proposed for reclaiming the dewatered construction water. The effect of concentration of steel slag and the effect of residence time was studied.

2 MATERIAL AND METHOD

2.1 Collection of water samples

Dewatered construction water samples were collected from a construction site located at the Industrial Area, 13 km away from the center of Doha city. Table 1 shows the composition of the dewatering construction water and the method of determination.

Table 1: Properties of the collected dewatering construction water and the determination method

Parameter	Unit	Sample	Testing methods
pH		7.59	SMWW 4500 H+.B
Turbidity	NTU	350	SMWW 2130 B
Total Solids (TS)	ppm	3,015	SMWW 2540 B
Total Suspended Solid (TSS)	ppm	91.2	Hach Method 8006
TDS (Calculated: TS -TSS)	ppm	2,924	SMWW 2540

2.2 Steel slag

The steel slag used in this study was provided by Qatar Steel. The composition of steel slag was analyzed using EDAX. The EDAX analysis in Figure 1 shows that 40% of the total weight of steel slag is made up of iron oxides and calcium oxides. In addition, other metals such as Magnesium (Mg) and Aluminum (Al) are present in small quantities. The steel slag particles have gravel like texture and a blackish color. Moreover, white dust particles are found within the steel slag. In order to remove the dust particles, the slag particles were washed with distilled water. Subsequently, the slag particles were grinded using a Planetary Ball Mill (PM 100 cm, Retsch) for 5 minutes at 500 RMP and then passed through 40-micron filter. Thus, collecting steel slag particles with an average size of 425 μm . The grinded steel slag can be seen in Figure 2.

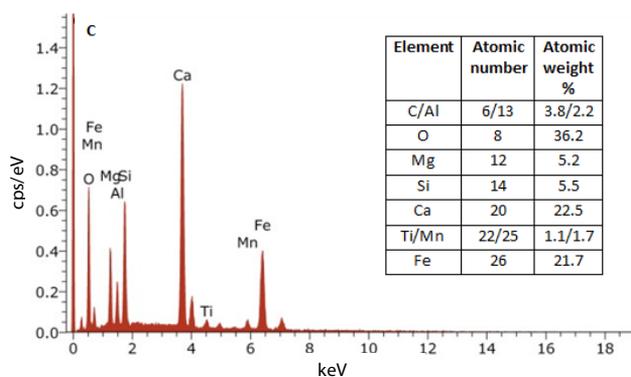


Figure 1: EDAX analysis of the slag sample prior to EC



Figure 2: Grinded steel slag sample

2.3 Experimental setup

After collecting the dewatered construction water and characterizing them, the removal of suspended solids was done to improve the turbidity of the water. It was done using jar test apparatus (PHIPPS & BIRD STIRRER 7790-402). The jar test apparatus can accommodate up to 6 beakers at the same time. 600 ml of water sample was added to each beaker in the beginning, this volume is enough to ensure that the stirrers is submerged in the water. After adding the steel slag, the sample was stirred for a fixed amount of time. During this process, the pH of the solution was maintained at 12. After mixing, the samples were allowed to stay still for few minutes for the suspended particles to settle down. After the coagulation process, the turbidity and total suspended solid concentration of the water was measured. The mass of steel slag and the contact time was optimized by repeating the experiment with varying the mass of steel slag

and contact time. After optimizing the process, the coagulation process was repeated with commercial chemical coagulants and its performance was compared with the performance of the proposed coagulant (steel slag).

After the experiment the total suspended solids removal and turbidity removal were calculated as (Hafiz, 2019):

$$TSS\ Removal\ \% = \frac{Original\ Sample\ TSS - Treated\ Sample\ TSS}{Original\ Sample\ TSS} \times 100\% \quad (1)$$

$$Turbidity\ Removal\ \% = \frac{Original\ Sample\ Turbidity - Treated\ Sample\ Turbidity}{Raw\ Sample\ Turbidity} \times 100\% \quad (2)$$

3 RESULTS AND DISCUSSION

3.1 Effect of steel slag concentration

The effect of steel slag concentration on the removal efficiency of total suspended solids (TSS) and turbidity was investigated. The pH of the dewatered construction water was 7.59. The used steel slag particles had a diameter of 425 nm. The test was run for 60 minutes and the TSS removal and turbidity removal were calculated after 60 minutes. The concentration of steel slag used was 5, 10, 15, 20 and 50 mg/L. As seen in Figure 3, when the concentration of steel slag was 5 g/L, the suspended solids removal rate was almost 97%. As the concentration of steel slag increased, the removal rate of suspended solids remained constant. When the concentration of steel slag was 50 mg/L, the removal rate of suspended solids decreased to reach 93.8%. Initially, the removal efficiency of suspended solid was high due to reduction of zeta potential of the water. Reduction of zeta potential reduced the surface charge of the colloids and made Van der Waals's force more dominant in the water. This caused faster agglomeration of colloids and increased TSS removal efficiency was observed (Shilton, 2006; Xiong, 2008; Yi, 2012; Liu, 2011). Using 5 g/L of steel slag resulted in turbidity removal rate of 97%. The turbidity removal rate did not improve by increasing concentration of the steel slag. On the contrary, increasing the steel slag concentration to 50 gm/L decreased the turbidity removal efficiency to 91.21%. This is because addition of excess steel slag increases the turbidity of the water.

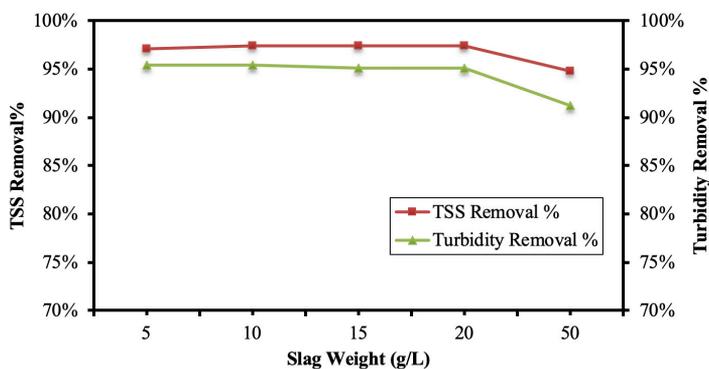


Figure 3: Different weights (g) of 425 nm steel slag turbidity and TSS removal % values

3.2 Effect of contact time

The impact of contact time on total suspended solid (TSS) and turbidity removal rate was also investigated. The concentration of the steel slag was kept constant at 5g/L. The TSS and turbidity removal rates were calculated after 5 minutes, 15 minutes, 30 minutes and 60 minutes of coagulation. Figure 4 shows the TSS and turbidity removal rate at different contact times. It can be seen, that after 5 minutes of contact time, the suspended solids removal rate was almost 60%. As the contact time increased, the removal rate of suspended solids also increased. As the contact time approached 60 minutes, the removal percentage of suspended solids reached about 91.6%. Similar trend can be seen for the turbidity removal rate. After 5 minutes of coagulation, the turbidity removal was 6.1%. The turbidity removal increased and reached 89.6% after 60 minutes of operation. It can be noticed that after 30 minutes of contact time, the TSS and turbidity removal rates do not improve significantly. This is mainly because, all the steel slag added has been used already and to improve TSS and turbidity removal rate, the concentration of steel slag in the water has to be increased.

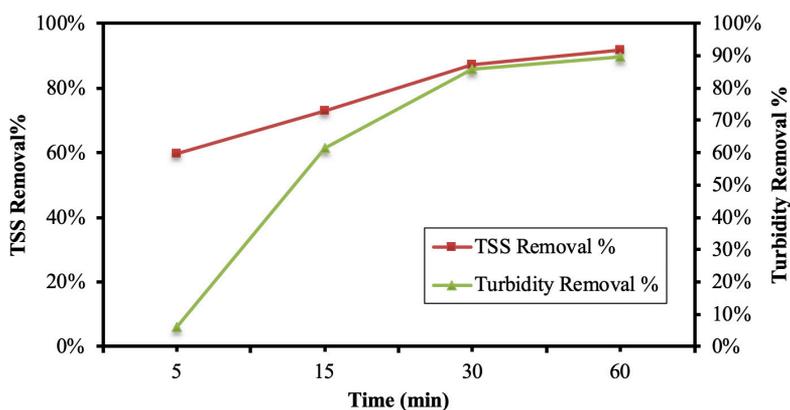


Figure 4: Turbidity and TSS removal % over time range (min) of 425 nm steel slag

4 CONCLUSION

In this study, a coagulation process has been proposed that utilizes steel slag as coagulant for treatment of dewatered construction water. The effect of concentration of the steel slag and contact time for the process on total suspended solid and turbidity removal rates have been studied. The pH of the dewatered construction water was 7.59 and the average radius of steel slag used for this study was 425 nm. The study showed that, by adding 5 gm/L of steel slag, 85% of TSS and turbidity can be removed within 30 minutes. In future, the size of steel slag particle and pH of the water would be studied to improve the performance of the coagulation process. Moreover, the performance of steel slag as coagulant would be compared with commercially available coagulants.

ACKNOWLEDGMENT

The authors would like to thank Qatar University for the financial support. In addition, the authors would like to thank Qatar Steel for the supply of the steel slag samples.

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Cite this article as: Al Hawari A., Tariq A., Yasir A. T., Ayari M. A., “Utilizing Steel Slag in the Removal of Suspended Solids from Dewatered Construction Water”, *International Conference on Civil Infrastructure and Construction (CIC 2020)*, Doha, Qatar, 2-5 February 2020, DOI: <https://doi.org/10.29117/cic.2020.0095>