APPLICATION OF COAGULATION PROCESS IN TREATING OF LANDFILL CONTAMINATED LEACHATE

Rabindra Chakrabarty*[1], Islam M. Rafizul[2] and Muhammed Alamgir[3]

[1]*Ex-Student, Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh, e-mail:rcb0901041@gmail.com*
[2]*Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh, e-mail: imrafizul@yahoo.com*
[3]*Department of Civil Engineering, Khulna University of Engineering & Technology (KUET), Khulna-9203, Bangladesh, email: alamgir63dr@yahoo.com*

ABSTRACT

The landfill leachate may be defined as a liquid or "waste juice" that percolates into the municipal solid waste (MSW) deposited in landfill having some inorganic, organic, metal, heavy metals, dissolved and suspended materials. The contaminated leachate from MSW landfills sporadically leaks and enters the surrounding areas. This leachate generally contains four groups of contaminants such as dissolved organic matter (alcohols, acids, aldehydes, short chain sugars etc.), inorganic macro components (common cations and anions including sulfate, chloride, iron, aluminum, zinc and ammonia), heavy metals (Pb, Ni, Cu, Hg), and xenobiotic organic compounds. This leachate is yellow or blackish colored cloudy liquid and the smell is acidic and offensive.

The research was carried out to determine the most appropriate type of coagulant and optimum dosages for removing of pollutants in leachate. The coagulation process was applied in treating the sample with coagulants of hydrogen peroxide (H_2O_2) and ferrous sulfate ($FeSO_4$) in the laboratory in various dosages with definite pH of 2, 4, 6, 8 and 10. It was found that TSS was removed maximum by 2000 mg/l of $FeSO_4$ at pH 5, likewise 2500 mg/l of $FeSO_4$ at pH 10, 2500 mg/l of $FeSO_4$ at pH 6 and 2500 mg/l of $FeSO_4$ at pH 6 are the optimum dosages for the maximum removal of color, turbidity and EC, respectively. Moreover, the maximum removal efficiency of TSS, color, turbidity and EC by $FeSO_4$ was found 75, 56.21, 52.68 and 40.85% respectively. In contrary, 10 ml/500ml of H_2O_2 at pH 10, 10 ml/500ml of H_2O_2 at pH 6, 4 ml/500ml of H_2O_2 at pH 10 and 6 ml/500ml of H_2O_2 at pH 6 were the optimum dosages for the maximum removal of TSS, color, turbidity and EC, respectively. In addition, the maximum removal efficiency of TSS, color, turbidity and EC by H_2O_2 was found 55.56, 63.22, 55.26 and 42.76%, respectively. Finally based on the experimental results, it can be concluded that $FeSO_4$ had the best performance to reduce TSS as well as H_2O_2 had the best performance to reduce the color, turbidity and EC.

Key words: *Landfill, solid waste, leachate, coagulation, removal efficiency*

1. INTRODUCTION

Increasing the quality of life and industrial and commercial growth in many countries around the world in the past decades have been accompanied by rapid increases in both municipal and industrial solid waste production. Municipal solid waste (MSW) generation continues to grow both in per capita and overall terms (Melike et al., 2007; Ajit Singh and Vidyarthi, 2008). And these solid wastes are usually dumped in a sanitary landfill in which well engineered solid wastes disposing methods are applied.

Sanitary landfill is defined as a disposal site that applies an engineered method of disposing of solid wastes on land in a manner that minimizes environmental hazards by spreading the solid wastes to the smallest practical volume, and applying and compacting cover material at the end of each day. Sanitary landfilling is an acceptable and recommended method for ultimately disposing of solid waste. The sanitary landfill is an engineered landfill that requires sound and detailed planning and specification careful construction, and efficient operation (Al – Yaqout et al., 2005). The physical appearance of leachate has when it seeps from a landfill site is a highly-odoured, yellow or blackish colored cloudy liquid and the smell is acidic and offensive. In some older landfills, leachate is directed to the sewers, but this can cause a number of problems. Toxic metals from leachate passing through the sewage treatment plant concentrate in the sewage sludge making it difficult or dangerous to dispose of to land without incurring a risk to the environment.

Leachates may contain large amounts of organic contaminants which can be measured as chemical oxygen demand (COD) and biological oxygen demand (BOD), ammonia, halogenated hydrocarbons suspended solid, significant concentration of heavy metals and inorganic salts. If not treated and safely disposed, landfill leachate could be a potential source of surface and ground water contamination, as it may percolate through soils and sub soils, causing pollution to receiving waters.

Coagulation-flocculation is a relatively simple technique that may be employed successfully for the treatment of landfill leachate. The removal mechanism of this process mainly consists of charge neutralization of negatively charged colloids by cationic hydrolysis products, followed by incorporation of impurities in an amorphous hydroxide precipitation through flocculation (Wang et.al.2009).

The objectives of this study were about the determination of the characteristics of untreated leachate and to find out the most appropriate coagulant type and optimum dosage for removing of TSS, Color, Turbidity and E.C. in leachate and studying of pH effect on removal efficiency.

2. METERIALS AND METHOD

2.1 Collection of sample

The accuracy of different parameters of leachate sample depends on the proper collection and preservation at correct temperature. Two leachate samples were collected from different pond situated at the south part of the sanitary landfill site, Rajbondh, Khulna city. The samples were collected in plastic containers from the collection ponds and immediately carried out to laboratory. Then the best was taken for treatment.

2.2 Sampling Method

Proper standard collection of leachate samples for analysis is of great importance. Representative samples were tested in the laboratory for the assessment of the existing pollutants and treatment options. The collected samples were transported to the laboratory quickly and then samples were preserved in refrigerator to keep at 4^0C. All possible efforts were made to minimize the time lag between collection and analysis so that no significant change may occur in the quality of the samples. Large particles and debris were removed to minimize particulate effects in oxidation reactions.

2.3 Quality Assessment of Rajbondh Landfill Leachate

The leachate parameters were determined including pH, color, turbidity, salinity, electric conductivity (E.C.) TDS, TS, TSS, DO_i, alkalinity, COD, BOD_5, total coliform and faecal coliform.

The pH and temperature were determined by the digital pH meter (HACH, Model No. Sension156). The turbidity was measured with an electronic turbidity meter. Color determined using spectrophotometer (HACH; DR/2400) according to Standard Methods APHA, AWWA and WEF (1998). Total alkalinity was measured by titration with 0.02N H_2SO_4. BOD_5 was measured by incubation in the dark at 20^0C for 5 days. COD was measured by titration (APHA 1998). Electric conductivity (EC) was determined by EC meter (HACH, model no. sension5). Total suspended and dissolved solids were dried to a constant weight at 105^0C. The comparison of different parameters of Rajbondh Landfill leachate with Bangladesh standards for discharging treated leachate into inland surface water are given in Table 1.

Table 1: Characteristics of raw leachate of Rajbondh landfill and comparison with Bangladesh standards for discharging treated leachate into inland surface water

Parameters	Unit	Raw leachate	Bangladesh standards for discharging treated leachate into inland surface water
pH	--	8.6	6-9
DO_i	mg/l	0.14	4.5-8
COD	mg/l	5760	200
BOD_5	mg/l	142.1	50
BOD_5/COD	--	0.0247	--
Alkalinity	mg/l	1700	--
Salinity	mg/l	2800	--
Temperature	^{0}C	28.7	--

EC	µS/cm	5.67	--
TSS	mg/l	400	150
TDS	mg/l	16600	2100
TS	mg/l	17000	--
Turbidity	NTU	336	--
Color	pt-co	17800	--
TC	Nos.	740	--
FC	Nos.	300	--

Some parameters exceeded the range of Bangladesh standards for discharging treated leachate into inland surface water and some were within the range. So the treatment should be done for discharging into inland surface to minimize harmful effect on environment. Coagulation process was carried on using the coagulants such as Ferrous Sulfhate ($FeSO_4$) and Hydrogen Peroxide (H_2O_2).

2.4 Chemical coagulation

By using Jar Test Apparatus in the physicochemical treatment experiments were investigated the effect of Ferrous Sulfate ($FeSO_4$) and Hydrogen Peroxide (H_2O_2) at various dosages and at some definite pH. Firstly, pH of samples were adjusted to desired pH (2, 4, 6, 8 and 10) and then $FeSO_4$ concentrations (500, 1000, 1500, 2000 and 2500 mg/l) at room temperature (20^{o}C) were dosed into 1 liter of a leachate sample. The fast mixing (110 rpm) for 3 minutes, slow mixing (50 rpm) for 30 minutes and 30 minutes settling time were applied sequentially in chemical precipitation. Similar procedure was carried out with Hydrogen peroxide (2, 4, 6, 8, and 10) ml/500ml. After that, the supernatant was analyzed for TSS, Color, Turbidity and Electric Conductivity concentration according to standard methods. The removal efficiency of TSS, Color, Turbidity and Electric Conductivity were obtained by using equation (1)

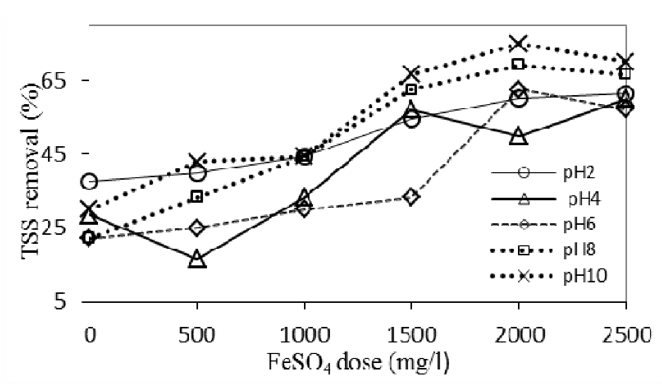
$$\textit{Removal Efficiency (\%)} = \frac{(C_0 - C_t)}{C_0} \times 100 \quad (1)$$

Where, C_0 and C_t are the initial and final concentrations of COD and TSS.

3. RESULTS AND DISCUSSIONS

3.1 Ferrous Sulfate Efficiency

After treatment of leachate with $FeSO_4$; the effect of various dosages of $FeSO_4$ at different pH values on the TSS removal efficiency in percentage is shown in Figure 1.



` Figure 1: The effect of Ferrous Sulfate dosages and pH on the removal of TSS concentration in leachate

It is observed that, generally the removal of TSS was increased with increasing concentration of added Ferrous sulfate.

The effect of various dosages of $FeSO_4$ and different pH values on the removal of Color is shown in Figure 2. Figure shows that removal of Color was increased with increasing concentration of added $FeSO_4$ except for the concentration of 1000 mg/l at both pH 6 and 10 and also 2000 mg/l at pH 2. The higher efficiency for Color removal by $FeSO_4$ was obtained at pH 10 and 2500 mg/l concentration of $FeSO_4$. The minimum removal efficiency of that was found 20.23% at without single dosage of $FeSO_4$ at pH 2.

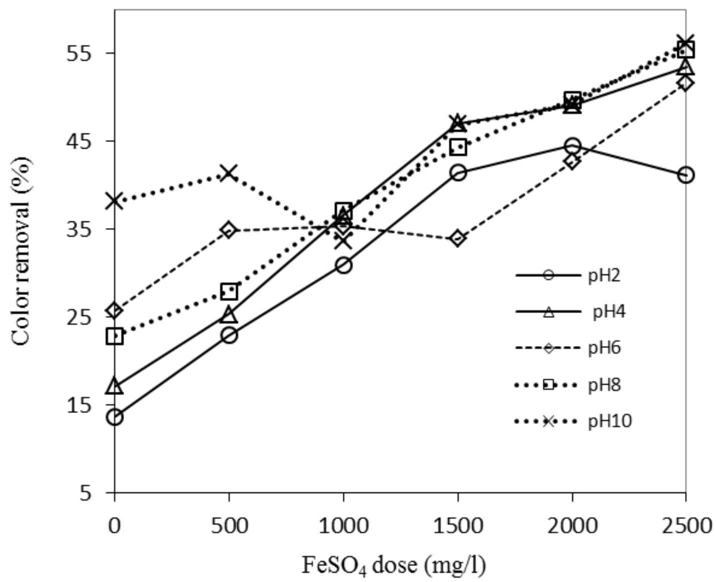


Figure 2: The effect of Ferrous Sulfate dosages and pH on the removal of Color concentration in leachate

After treatment of leachate with $FeSO_4$; the effect of various dosages of $FeSO_4$ at different pH values on the Turbidity removal efficiency in percentage is shown in Figure 3.

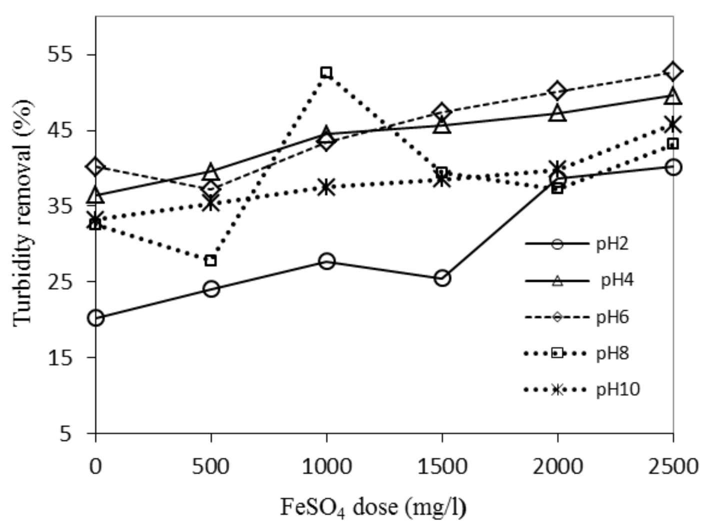


Figure 3: The effect of Ferrous Sulfate dosages and pH on the removal of Turbidity concentration in leachate

It is interesting to note that the Turbidity removal efficiency in leachate varies with in relation to the increasing of coagulant dosages. It can be concluded that the optimum removal efficiency of Turbidity was 52.68% using $FeSO_4$ at optimum dosage of 2500 mg/l at pH 6, while, the minimum removal efficiency of that was found 20.23% at without single dosage of $FeSO_4$ at pH 2.

After treatment of leachate with $FeSO_4$; the effect of various dosages of $FeSO_4$ and different pH values on the E.C. removal efficiency in percentage is shown in Figure 4.

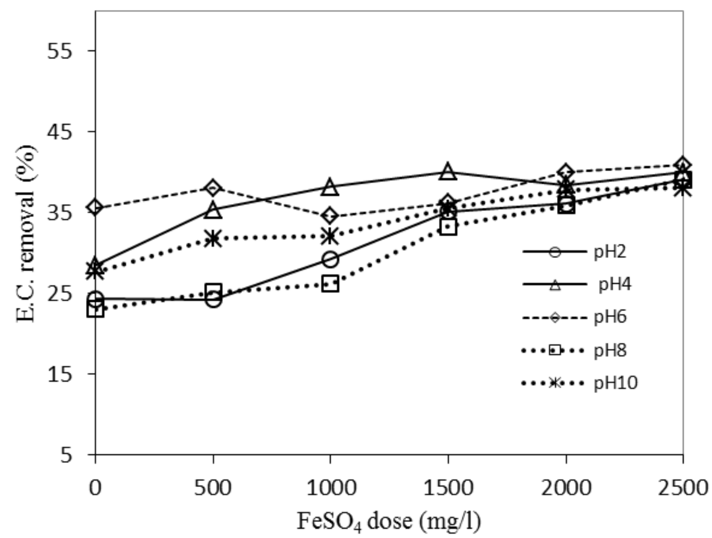


Figure 4: The effect of Ferrous Sulfate dosages and Ph on the removal of E.C. concentration in Leachate

It is interesting to note that the E.C. removal efficiency in leachate varies with in relation to the increasing of coagulant dosages. It can be concluded that the optimum removal efficiency of E.C. was 40.85% using $FeSO_4$ at optimum dosage of 2500 mg/l at pH 6, while, the minimum removal efficiency of that was found 23.02% at without single dosage of $FeSO_4$ at pH 8.

3.2 Hydrogen Peroxide Efficiency

The effect of various dosages of H_2O_2 and different pH values on the TSS removal efficiency is shown in Figure 5. It is observed that the removal of TSS generally less than Hydrogen peroxide.

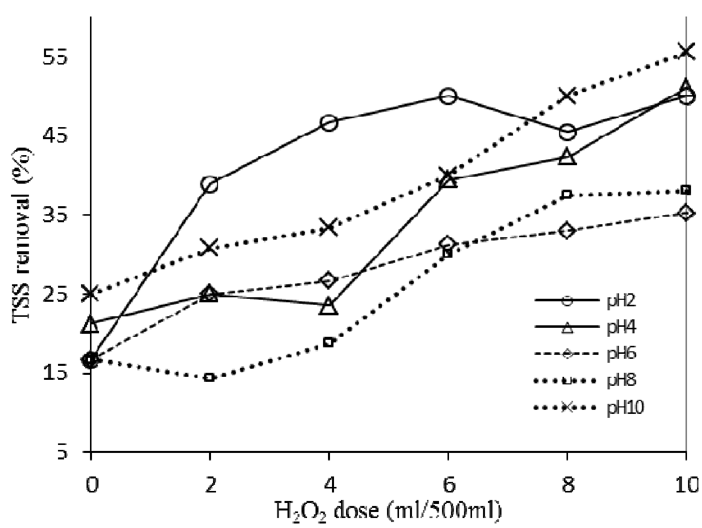


Figure 5: The effect of H_2O_2 dosages and pH on the removal of TSS concentration in leachate

It should be mentioned that the TSS removal efficiency in leachate varies with in relation to the increasing of coagulant dosages. It can be concluded that the optimum removal efficiency of TSS was 55.56% using H_2O_2 at optimum dosage of 10 ml/500ml at pH 10, while the minimum removal efficiency of that was found 16.67% at 0 ml/500ml dosage at pH 8.

After treatment of leachate with H_2O_2, the effect of various dosages of H_2O_2 and different pH values on the Color removal efficiency in percentage is shown in Figure 6.

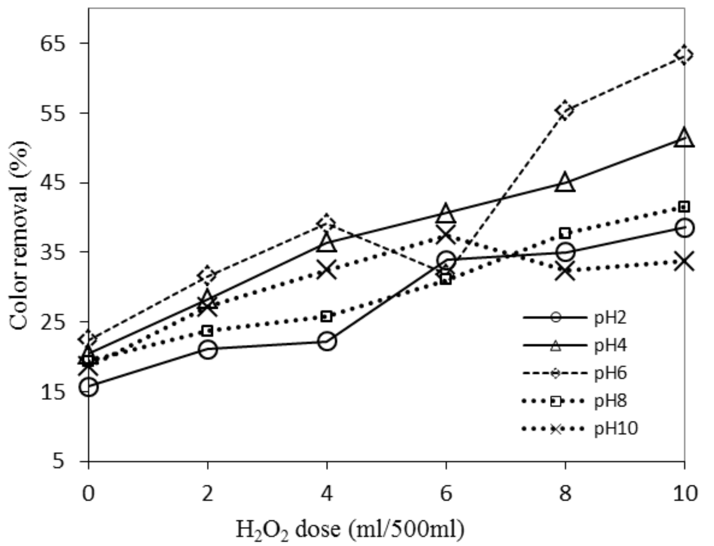


Figure 6: The effect of H_2O_2 dosages and pH on the removal of Color concentration in leachate

It should be mentioned that the Color removal efficiency in leachate varies with in relation to the increasing of coagulant dosages. It can be concluded that the optimum removal efficiency of Color was 63.22% using Color at optimum dosage of 10 ml/500ml at pH 6, while, the minimum removal efficiency of that was found 15.7% at 0 ml/500ml dosage at pH 2. The figure shows color removal efficiencies increased gradually with the increase of dosage. But further improvement in and color removal efficiencies beyond a certain amount of dosage gave milder increased removal efficiencies. This indicated that the end by-products of oxidation reactions are mainly made of short chain organic acids that are difficult to be further oxidized (Lopez, et al., 2004).

After treatment of leachate with H_2O_2; the effect of various dosages of H_2O_2 and different pH values on the Turbidity removal efficiency in percentage is shown in Figure 7.

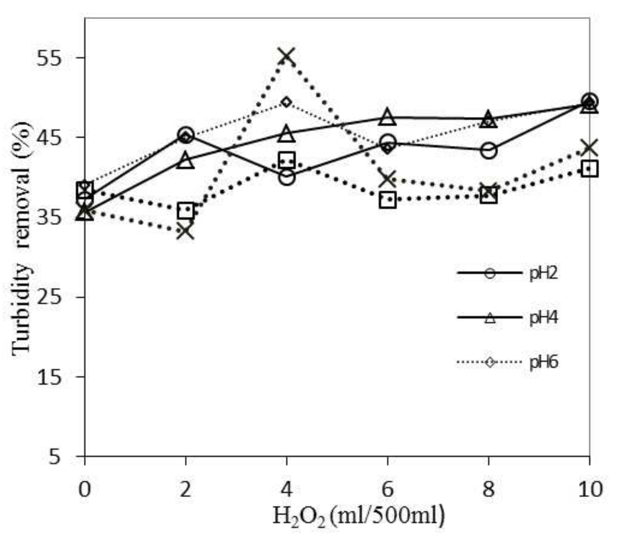


Figure 7: The effect of H_2O_2 dosages and pH on the Removal of Turbidity concentration in leachate

Based on the above figure it is seen that Maximum Turbidity removal 55.26% at pH 10 and optimum Hydrogen Peroxide dose 4 ml/500ml.

After treatment of leachate with H_2O_2, the effect of various dosages of H_2O_2 and different pH values on the E.C. removal efficiency in percentage is shown in Figure 8.

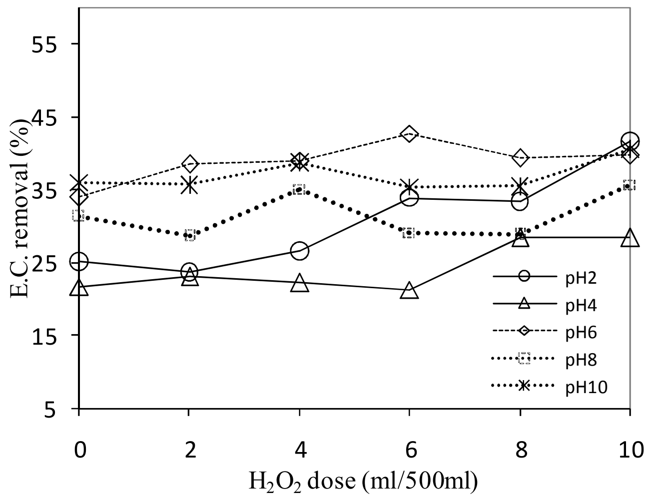


Figure 8: The effect of H_2O_2 dosages and pH on theremoval of E.C. concentration in leachate

The E.C. removal efficiency in leachate varies with in relation to the increasing of coagulant dosages. It can be concluded that the optimum removal efficiency of E.C. was 42.76% using H_2O_2 at optimum dosage of 6 ml/500ml at pH 6, while, the minimum removal efficiency of that was found 21.33% at 6 ml/500ml dosage at pH 4.

Based on the observed results it is clear that the maximum removal efficiency for TSS by Ferrous Sulfate and Hydrogen Peroxide are 75% at 2000 mg/l and 55.56% at 10 ml/500ml respectively. And for the maximum removal efficiency for Color by Ferrous Sulfate and Hydrogen Peroxide are 56.21% at 2500 mg/l and 63.22% at 10 ml/500ml respectively. Also the maximum removal efficiency for Turbidity by Ferrous Sulfate and Hydrogen Peroxide are 52.68% at 2500 mg/l and 55.26% at 4 ml/500ml respectively. Finally for the maximum removal efficiency for E.C. by Ferrous Sulfate and Hydrogen Peroxide are 40.85% at 2500 mg/l and 42.76% at 6 ml/500ml respectively (Figure 9). Based on results of this study, the best coagulant for TSS removal was Ferrous Sulfate and Hydrogen Peroxide was the best coagulant for Color, Turbidity and E.C. removal and the physico-chemical process may be used as an effective pretreatment process, especially for young leachate, prior to post-treatment (polishing) for partially stabilized leachate.

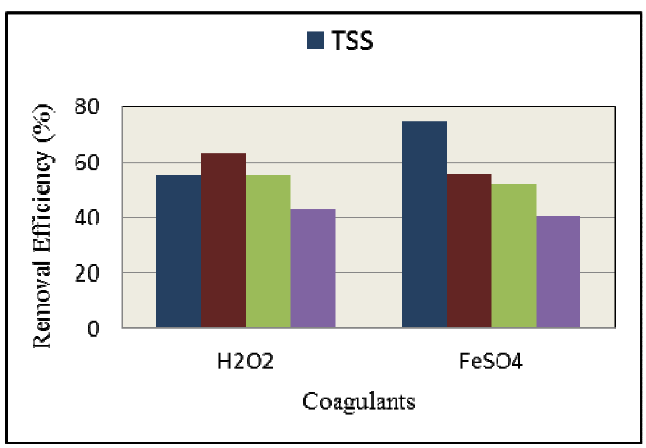


Figure 9: Optimum results of leachate treatment by coagulation with various coagulants at optimum conditions

3.3 Comparison with the Standard Tools

Comparison of treated leachate with treated leachate and Bangladesh standard shown in Figure 10.

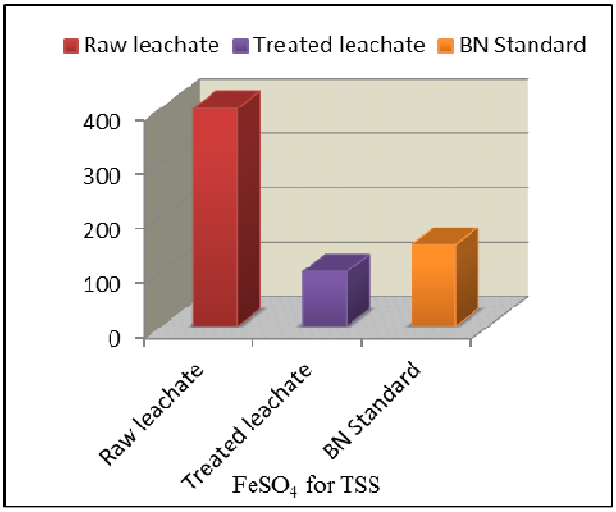


Figure 10: The effect of $FeSO_4$ on the removal of TSS in the leachate at optimum conditions compared to the different standards

4. CONCLUSIONS

The main purpose of this study was to determine the most appropriate type of coagulant and optimum dosages for removing of pollutants in leachate by Coagulation-Flocculation Process. Raw leachate was characterized to compare with Bangladesh standards for discharging treated leachate into inland surface water. The coagulation treatment was done using ferrous sulfate and hydrogen peroxide. Based on the experimental results, it can be concluded that Ferrous Sulfate had the best performance to reduce of pollutants with the optimum dosage of 2000 mg/l at pH 10 for TSS and Hydrogen Peroxide had the best performance to reduce the Color, Turbidity and E.C. To investigate the performance of removal of contaminants in leachate using coagulants at varying concentrations and pH may be represented by the curve pH verses pollutants removal. Finally, here, it is interesting to note that after reducing the relevant pollutants hence compared with the standard tools available in the literature and are agreed well.

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