TREATMENT OF RIVER WATER OF SG. PUSU BY USING MAGNESIUM OXIDE (MGO) COATED WITH CHITOSAN

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ABSTRACT: Effective treatment of wastewater is crucial in order to achieve a sustainable development. For instance, highly efficient treatment processes with low capital requirements are the major prerequisite for implementation of the advanced wastewater treatment operations. Among various available treatment methods, the application of coagulation-flocculation process by using natural coagulant; chitosan has vast advantages such as low operating cost, environmental friendly and highly effective in the wastewater treatment operations. The application of nanotechnology in numerous treatment techniques are considered as the most significant advances in water and wastewater treatment practices. The utilization of magnesium oxide (MgO) as nano-adsorbent has recently gained attention as a potential treatment method in water remediation particularly for treating effluents with high amount of organic dyes and heavy metals due to its high treatment efficiency, low cost, versatility and environment compatibility. The purpose of this study was to determine the effectiveness of coagulation-flocculation process when using novel coagulant in which MgO coated with chitosan by investigating the percentage removal of several significant parameters which were turbidity, chemical oxygen demand (COD) and suspended solid. The removal efficiencies were determined throughout a series of experiments carried out using a standard jar test procedure in which three different coagulants; chitosan, MgO coated with chitosan and MgO were tested on water samples taken from Sg. Pusu. In addition, a set of experiments was designed using response surface methodology (RSM) in order to optimize adsorption of chitosan into MgO. The experiments were conducted at various concentrations of chitosan (10-30 mg/ml) and selected MgO dosage ranges (10-30 mg). From the obtained results, it was found that chitosan-MgO coagulant has good removal efficiencies of turbidity, chemical oxygen demand (COD) and suspended solids at 92%, 91%, and 98% respectively from the optimization of adsorption of chitosan-MgO. The MgO coated with chitosan is the best coagulant in this study compared to chitosan and MgO alone because of the ability of treating the river water with up to 90 % removal for all the main parameters. The results showed that coagulation-flocculation is effective as a treatment for treating river water.

KEY WORDS: *Chitosan; Magnesium Oxide (Mgo); Wastewater Treatment; Coagulation-Flocculation*

1. INTRODUCTION

Water is one of the world's most crucial resources which is a basic need required for every human being and living creature specifically. Fresh water supply is required not just for drinking but also for many different purposes such as farming, bathing, electrical production, industrial processes and manufacturing and many other activities. However, water resources across the world are facing pressures due to tense population growth, climate changes and rapid economic growth which lead to rapid urbanisation and industrialization. These issues have prompting an expanding interest for fresh water supply thus resulting in water scarcity due to lack of sufficient available water resources to cater the massive demands of water usage around the globe.

In order to overcome this problem, one of the available solutions is throughout water and wastewater reuse. Generally, water is discarded as water upon being used for beneficial and economic purposes. Wastewaters disposed from homes, business premises and industries will be discharged into natural watercourses either as treated effluent or untreated waste and then will be subjected to "self-purification" within the streams, in which they will be extracted for future use [1]. The system of indirect reuse permits wastewater to be reused multiple times as domestic water supply before being discharged back to the ocean while direct reuse is also possible throughout the development of high-end technology associated with reclamation of wastewaters either as process or potable water resources. The adaptation of various wastewater treatment practices and subsequent reuse as a means of overcoming limited freshwater supply is considered as a feasible options for toilet flushing, agricultural purpose and some industrial activities such as for cooling water or cleaning purposes [2].

Regulations and legislations have been established to control wastewater discharges into the environment while maintaining water quality standards to be adhered to by local authorities. This lead to large number of conducted studies that fully elucidate principles and fundamentals of wastewater treatment practices to come out with good practices and solutions to produce safe water and wastewater for both living organisms and environment.

Numerous studies have been performed to obtain practical and efficient wastewater treatment strategy, depending on their characteristics. These include coagulation-flocculation [3], membrane separation [4], filtration [5], oxidation [6], precipitation [7] and adsorption [8]. Prior distribution of the treated effluent to the consumer, the common treatment techniques employed in most water treatment industry are coagulation-flocculation process followed by sedimentation, filtration and disinfection by chlorine [9]. The physicochemical principle behind coagulation is the negatively charged of colloidal particles in water such as microorganism and clays will be destabilized by the positively charged of coagulant in such a way that the coagulant causes these suspended, dispersed particles to destabilize and agglomerate to form large, dense structures (flocs) that will precipitate and create sedimentation [10].

In conventional wastewater treatment operations, coagulants are widely utilised for production of potable water and these coagulants can be divided into three main categories such as naturally occurring coagulant, inorganic coagulant and synthetic organic polymer [11]. Moreover, coagulant such as synthetic polyelectrolytes can also be utilised as coagulant aid in order to increase the aggregation of particles and eventually, enhanced both coagulation and deposition (filtration) processes [12]. Generally, natural occurring coagulants are extracted or produced from living creatures such as microorganisms, plants or animals and they often presumed to be safe for human consumption [13]. There is a recent resurgence of interest in utilisation of natural coagulants in coagulation-flocculation process for wastewater treatment practices in many developing countries.

Chitosan is a natural occurring polymeric coagulant which can be extracted from crustacean shells or fungal biomass. Natural biological characteristics and biodegradability are the primary factors chitosan-based materials have been acknowledged and suggested as potentially eco-friendly coagulants and flocculants for water and wastewater treatment system [14]. Chitosan can be used as renewable bio-flocculants that are prepared by de-acetylation of chitin, a major component of the shells of crustaceans such as shrimp or crabs. Another attractive trait of chitosan which make it more effective for treating industrial wastewater is because it has powerful adsorptive capacity since it contains two reactive hydroxyl groups and highly reactive amino acid groups [15].

To date, one of the most advanced processes for wastewater treatment is the application of nanotechnology in the treatment practices [16]. Nano-materials can be classified into three primary categories which are nano-adsorbents, nano-catalysts and nano-membranes [17]. In nano-adsorption technology, many works have been published in order to investigate the effectiveness of nano-adsorbents in removing the contaminants and pollutants from wastewater. Magnesium oxide (MgO) as nano-adsorbents often being selected due to its attractive traits such as non-toxic, environmentally friendly, abundant and has high adsorptive ability which is very effective for removal of organic dyes, phosphates and heavy metals from wastewater.

At this very moment, Sungai Pusu which flows throughout International Islamic University of Malaysia (IIUM), Gombak Campus at downstream is highly polluted due to sand mining activities upstream was chosen as sampling location in this project. In this project, MgO coated with chitosan will be prepared to treat river water sample of Sungai Pusu and the effectiveness of this novel coagulant will be investigated and studied based on different parameters such as for removal of suspended solids, chemical oxygen demand (COD), turbidity, heavy metal ions and biological oxygen demand (BOD). To the best of author's knowledge, there is no other studies adopt the usage of MgO coated with chitosan for Sungai Pusu river water treatment. Hence, this study is considered a novel study carrying an attempt to perform river water treatment in Sungai Pusu.

Therefore, the aim of this study is to utilize the novel coagulant of MgO coated with chitosan for Sungai Pusu river water treatment. The preparation of the MgO micro particles, the optimization study of the chitosan adsorption and the efficiency of the novel coagulant will be discussed in detail.

2. MATERIALS AND METHODS

2.1 Analysis of Raw Wastewater Characteristics

Sample of river water (3°14'23.9"N 101°43'06.9"E) was obtained from Sungai Pusu and collected directly into sampling bottles. About 10 L was collected and kept in the chiller (4°C) until further usage. To obtain minimal microbial activities, river water samples were used promptly once collected. The parameters relevant to these samples were presented in Table 1.

Table 1: Parameters indicating quality of Sungai Pusu collected for studies

Parameters	Values
pH	7.0
Chemical Oxygen Demand (COD)	6.8 mg/L
Biological Oxygen Demand (BOD)	909 mg/L
Total Dissolved Solid (TDS)	48.6 mg/L
Total Suspended Solid (TSS)	3706 mg/L
Turbidity	1000 NTU

2.2 Synthesis of MgO

A 25 mL of 1M sodium carbonate (Na_2CO_3) solution was pumped into 25 mL of 1M magnesium chloride ($MgCl_2.6H_2O$) solution with a flow rate of 10.5 mL min^{-1} using a peristaltic pump. The solution mixture was incubate in a water bath at 50°C for 2 hours. The samples were cooled at room temperate prior filtration process. The solution mixture will then be filtered using filter paper with pore size (11 µm) to separate the produced white precipitates. The white precipitates was collected and left to dry at room temperature (or 50°C) for overnight. The white precipitates was then subjected to muffle furnace at 500°C for 5 h in order to obtain a flowerlike porosity structure of MgO.

2.3 Preparation of Chitosan

Chitosan powder (100 mg) was weighed accurately and put in the glass beaker. About 10 mL of 0.1M HCl was added into the glass beaker and mixed with the chitosan powder. The mixture will be continuously stirred using a magnetic stirrer for 1 hour to dissolve the chitosan powder. An appropriate dilution with distilled water will be performed in order to achieve 1 mg chitosan per mL of solution. The solutions were freshly prepared prior to each experiment.

2.4 Experimental Design

A response surface methodology was used to determine the relationship between the chitosan concentration, MgO dosage and time for the adsorption of MgO into chitosan. This rotatable experimental plan was carried out as a Face Central Composite Design (FCCD). For three variables (n = 3) and three levels (low (-), medium (0), and high (+), the total number of experiments was 8. The three-factor FCCD implemented in this study is given in Table 2 to study the effects of three independent operating variable conditions on the response (adsorption of chitosan into MgO). The factors were chitosan concentration, weight of MgO and period of loading (time).

Table 2: Parameters and Levels used in Factorial Central Composite Design

Variable (Factors)	**Factor Coding**	**Unit**	**Levels**		
			Low (-1)	**Medium (0)**	**High (1)**
MgO dosage	A	mg	10	20	30
Chitosan concentration	B	mg/mL	10	20	30
Time	C	hours	12	24	36

2.5 Coagulation-Flocculation Process by Jar Test

A conventional jar test apparatus, Phipps & Bird Six-Paddle Stirrer was employed for the tests. All tests were carried out in 1 L beakers. From the optimization result of MgO loading into chitosan, several analysis on the efficiency of coagulants: chitosan, chitosan-MgO and MgO had been studied using jar test experiments. Coagulants was added to the samples at a flash mixing speed of 200 rpm for 4 minutes and stirring speed was then lowered to 60 rpm for 30 minutes. At the end of stirring period, the beakers were removed slowly and the flocs was allowed to settle for one hour.

2.6 Turbidity Test

The turbidity levels of river waters are required to be tested prior and after treatment. A 10 ml of river water samples was poured into the turbidity tube and the tube was put inside the turbidity meter. The reading from turbidity meter was recorded for further analysis.

2.7 The Chemical Oxygen Demand (COD) Test

A 10 ml of river water samples was poured into three different 100 ml conical flasks that were labelled according to the type of coagulants use. The distilled water acted as the blank solution. A 5 ml of potassium dichromate solution was inserted into each of conical flask. Then, the conical flasks were kept in the water bath at 100°C for 60 minutes. After that, samples were left for 10 minutes under room temperature for cooling off. Next, a 5 ml of potassium iodide and a 10 ml of sulphuric acid were added into each conical flask. A titration process was performed for each flask by using 0.1 N sodium thiosulphate until the blue colour completely disappears.

2.8 Total Suspended Solid (TSS) Determination

A filtration process was carried out by using filter paper (pore size of 11 µm) to filter the suspended particles presents in the river water samples. The initial weight of the filter paper was weighed using analytical balance. Next, pre-weighed filter paper was placed inside the filter holder with the wrinkled surface up. The filter holder was assembled into a 250 ml filter flask. The filter paper was washed with deionised water to ensure strong adhesion to the holder. A 50 ml of river water samples was transferred to the filtering apparatus while vacuum is applied. Upon filtration completed, the wet filter paper was left to dry in oven at 100°C for one hour. Next, the filter paper was taken out and left to cool at room temperature inside desiccators before being weighed again on the same analytical balance. A gravimetric analysis was used to obtain the reading of total suspended solid (TSS). TSS was part of total solid retained on filter paper after drying process. The calculation step was performed in order to calculate the amount of TSS by using Eq. (1).

$$L, mg\ TSS = \frac{(x-y)\times 1000}{sample\ volume\ (ml)} \tag{1}$$

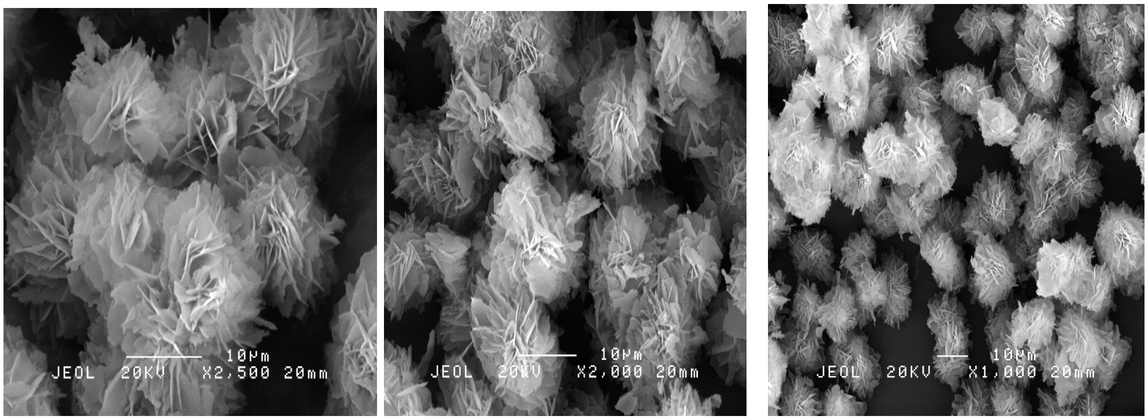
3. RESULTS AND DISCUSSION

3.1 Characterization of MgO using Scanning Electron Microscopy (SEM)

Magnesium oxide (MgO) micro particles were prepared and characterised using scanning electron microscopy (SEM). The SEM analysis provided information about the size and the surface morphology of MgO. The morphology and size distribution of MgO nanoparticles was investigated by FE-SEM (Fig 1).

The SEM images showed MgO micro particles in a flower-like structure which only can be obtained after calcination process where the MgO was being heated in the furnace at a high temperature of 500 °C for duration of 5 hours. Therefore, calcination was a very crucial step in order to obtain desired MgO micro particles with porous and flower-like structure thus, improved the absorption capacity of MgO-chitosan coagulant during the treatment process

The high magnification of SEM image of MgO micro particles showed a clearer porous and flake structure compared to the images produced in medium and low magnification. All images showed high porosity with uniform distribution of synthesized MgO nanoparticles and particle size ranging from 20 mm (Fig.1). The porous is where the chitosan will be adsorbed into the MgO micro particles in order to produce MgO-chitosan coated. This is because the rate of reaction also increases when the temperature increases. The surface of particles become activated and eventually increases the adsorption capacity. This phenomenon is known as endothermic in which the adsorption processes are enhanced at relatively high temperature as compared to the low temperature where the adsorption capacity of MgO micro particles to adsorb chitosan are relatively low [18].



(a) (b) (c)

Fig. 1: FE-SEM images for different magnifications. (a) SEM image of micro particles with high magnification. (b) SEM image of MgO micro particles with medium magnification. (c) SEM image of micro particles with low magnification.

All elements were also analysed in Normalised method as processing options. It can be identified that no other elements or substances present in the MgO micro particles as the total for each spectrum is 100 which means it is only occupied with elements of magnesium (Mg) and oxide (O). A success conformation of MgO micro particles with a good distribution was presented in Table 3.

Table 3: The content of MgO based on spectrum

Spectrum	**O**	**Mg**	**Total**
Spectrum 1	55.5	44.5	100.00
Spectrum 2	55.39	44.61	100.00
Spectrum 3	60.18	39.82	100.00
Spectrum 4	61.96	38.04	100.00
Spectrum 5	54.66	45.34	100.00
Max.	61.96	45.34	
Min.	54.66	38.04	

*All results are in Weight Percent

Based on results obtained from Table 3, EDX analysis was conducted in order to determine the chemical composition of magnesium and oxygen. Fig. 2 demonstrates the result of EDX analysis for MgO micro particles.

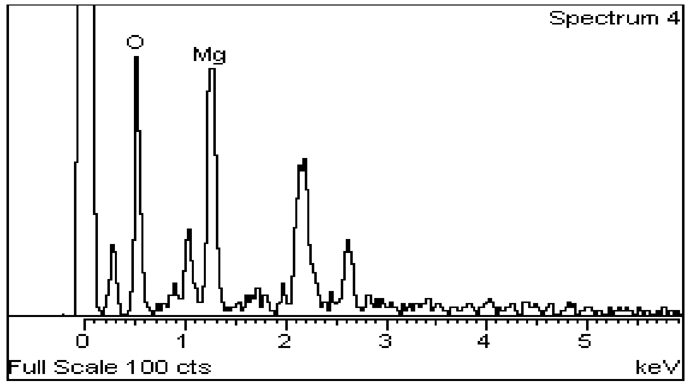


Fig. 2: XRD patterns of synthesized MgO micro particles

The results of EDX analysis for MgO micro particles showed that values for maximum peaks of oxygen and magnesium elements were 61.96% and 45.34% respectively, which indicated that the spectrum was mainly occupied by both elements. However, the present of small and low unknown peaks were discovered in the XRD patterns, indicated that contamination may occur during synthesis process and thus, unable to declare the purity of MgO micro particles produced. Contamination by dust or microorganism could occur during the synthesis process of MgO due to improper cleaning of workplace or usage of unclean or dusty apparatus as well as exposure to the ambient air during transportation of MgO samples between different laboratories (from synthesis process by calcination in furnace to analysis process by SEM and EDX).

3.2 Optimization of Adsorption of Chitosan-MgO Micro Particles

In order to perform river water treatment, a novel adsorption process of chitosan-MgO micro particles was established. Preliminary results revealed that dosage of MgO, concentration of chitosan and time are the key physical factors affecting the adsorption process by the coagulant. The FCC was applied in this experiment to identify the effects of the individual factors and the interactions between factors, as well as to determine the optimum conditions for the system. The upper and lower levels of each variable were chosen based on preliminary experiments. The experimental data analysis, along with predicted data obtained from the regression equation by FCC is shown in Table 1. There was wide variation in the adsorption values in the 20 run experimental combinations elucidating the importance of this optimization study.

The importance variable factors which required to be examined were MgO dosage, chitosan concentration and time (hours). The amount of chitosan adsorbed into MgO can be determined by deducting the initial reading of chitosan concentration with the final reading of the concentration. A total of 20 experiments with different combination of chitosan concentration, dosage of MgO and period of loading were performed. Each response was analysed through fit summary, model selection, analysis of variance (ANOVA), model diagnostic, and model graphs including 2D and 3D graphs.

The analysis of variance (ANOVA) of RSM is crucial in identifying the significance of the quadratic model produced. The ANOVA of RSM model is presented in Table 4 below. The model was statistically significant with the probability of $p < 0.05$ and the confidence interval of greater than 95%. The regression model showed that the model is significant based on F-test with a low probability (p model < 0.001).

Normally, the significance of the variables is highly dependent to the p-value where smaller p-value indicates higher significance of each variable (Include references). The contributions of both individual and combined components were indicated by the values of the coefficient of equations (Table 4). The most important factors determining the adsorption of MgO-chitosan was chitosan concentration with the highest coefficient (817.36), which indicates that it is the most dominant factor influencing the overall adsorption reaction process followed by MgO concentration (47.34) and loading time (23.71).

According to the ANOVA Analysis (Table 4), the Model F-value of 13.27 implies the model is significant. There is only a 0.02% chance that a "Model F-Value" this large could occur due to noise. Values of "Prob > F" is less than 0.0500 thus, indicates model terms are significant. In this case A, B, B^2 are the significant model terms.

Values greater than 0.1000 indicate the model terms are not significant. The "Lack of Fit F-value" of 0.26 implies the Lack of Fit is not significant relative to the pure error. There is a 91.65% chance that a "Lack of Fit F-value" this large could occur due to noise. Non-significant lack of fit is good indicates the model is fit. The Pred R-Squared of 0.7676 is in reasonable agreement with Adj R-Squared of 0.8532. Adequate Precision measures the signal to noise ratio and it is desirable to be greater than 4. By referring to Table 4, the ratio of 12.429 indicates an adequate signal. Therefore, this model can be used to navigate the design space.

In order to determine the optimal values of the variables within the range, 3D response surface was used. The graphical view of regression equation was presented. From 3D response surface plots, the optimal values of independent variables and the corresponding response could be predicted and understood. Fig. 3 (A) (B) illustrates the 3D surface graphs.

The 3D surface graph of chitosan concentration versus MgO dosage in the Fig.3 (a) showed adsorption reduced at the condition where the chitosan and concentration dosage at 10 mg/ml. This indicated that minimum adsorption occurred when minimum concentration for both chitosan and MgO were used. Meanwhile, the maximum adsorption occurred when maximum concentration of chitosan and dosage of MgO were used.

Fig. 3(b) showed the interaction between MgO dosage and time (hour) with the concentration of chitosan. The pattern of this graph indicated that the highest percentage of adsorption was obtained generally at the 30 mg/mL of MgO dosage and 12 hours. Therefore, the highest of adsorption can be achieved with the highest MgO dosage but with lowest of time (hour).

Table 4: Analysis of Variance Table

Source	Sum of Squares	DF	Mean Square	F Value	Prob>F	
Model	1006.24	9	111.80	13.27	0.0002	*significant*
A	47.34	1	47.34	5.62	0.0393	
B	817.36	1	817.36	97/00	<0.0001	
C	23.71	1	23.71	2.81	0.1244	
A^2	2.28	1	2.28	0.27	0.6141	
B^2	64.07	1	64.07	7.60	0.0202	
C^2	5.63	1	5.63	0.67	0.4328	
AB	8.45	1	8.45	1.00	0.3402	
AC	1.02	1	1.02	0.12	0.7347	
BC	0.34	1	0.34	0.040	0.8446	
Residual	84.27	10	8.43			
Lack of Fit	17.45	5	3.49	0.26	0.9165	
Pure Error	66.81	5	13.36			*Not significant*
Cor Total	1090.50	19				

Std.Dev	2.90	R Squared	0.27
Mean	7.90	Adj R-Squared	0.8531
C.V	5.02	Pred R-Squared	0.7676
PRESS	53.41	Adeq Precision	12.429

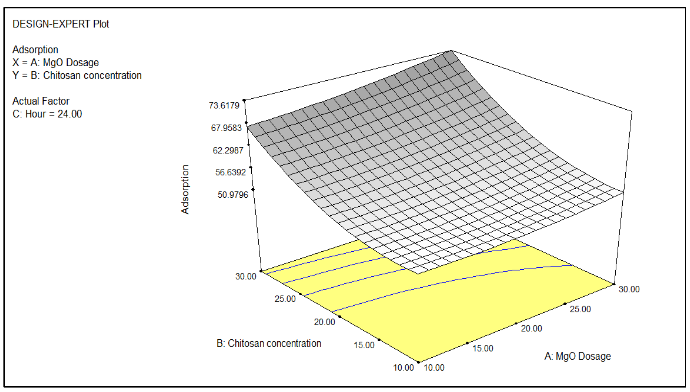


Fig. 3 (A): 3-D response for AB interaction (MgO dosage-chitosan concentration)

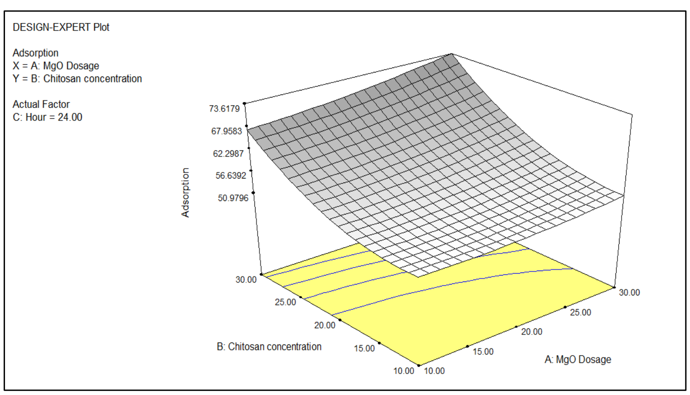


Fig.3 (B): 3-D response for AC interaction (MgO dosage-time)

3.3 Optimization of Coagulation-Flocculation

From the optimization result of MgO loading into chitosan, several analysis on the efficiency of coagulants; chitosan alone, chitosan-MgO and MgO alone had been studied using a series of experiments by jar test. The results obtained showed that chitosan-MgO was more effective in the removal of turbidity compared to chitosan and MgO alone. The results of turbidity removal were recorded by each half an hour for each coagulant used; chitosan alone, chitosan-MgO and MgO alone and were demonstrated in Fig. 4.

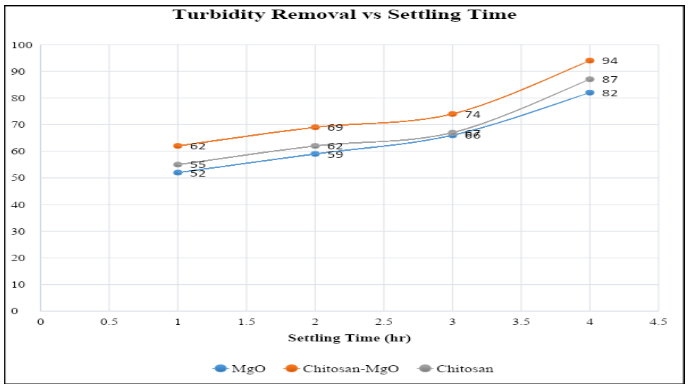


Fig.4: Effect of turbidity percentage removal for chitosan, MgO and chitosan-MgO

Based on Fig. 4, the turbidity test showed coagulant (chitosan-MgO) gave higher turbidity removal compared to chitosan and MgO alone. The low amount of turbidity removal by using chitosan and MgO alone might due to their chemical characteristics did not counterpart much with coagulation-flocculation process. The removal percentage for turbidity by using chitosan-MgO coagulant in the coagulation-flocculation treatment process was recorded at 92%. This result could be attributed to the effectiveness of the chitosan-MgO as a coagulant for the treatment of river water. Although chitosan has the potential to effectively removed turbidity for the treatment of river water via coagulation process but, coagulation process alone could not achieve the required standard for potable water due to the deteriorating raw water quality and implementation of a more stringent water quality regulation.

The combination of chitosan and MgO was able to produce a stronger coagulant which can improve the coagulation process and highly efficient for removal of turbidity and heavy metal. The coagulation-flocculation process is a treatment technique that was widely used in many water treatment systems due to its simple operation along with cost-effective [19]. The ballasted flocculation units commonly function through the addition of coagulant such as chitosan. When coupled with chemical addition such as magnesium oxide (MgO), the ballast material was seen to be totally effective in coagulation-flocculation process.

The widely used adsorbent to treat river water is activated carbon particularly due to its effectiveness in removing turbidity, COD, TSS and heavy metals. The drawback of activated carbon is not economical friendly material despite being an effective component which can greatly eliminate high amount of suspended particles and heavy metals [20]. In addition, complex chemical agents are required in order to raise the removal performance for organic and inorganic compounds.

Due to the issue mentioned above, an alternative adsorbent which is able to reduce and eliminate the high concentration of pollutant loads from river water at relatively low cost is preferred. The coagulation-flocculation process operates with addition of micro particles of magnesium oxide (MgO) which function to enhance particle formation and ultimately the generated ballast aid in rapid settlement of coagulated material [21]. Hence, chitosan-MgO can increase the efficiency of leachate treatment process in respect for removal of suspended solids, BOD, COD and turbidity.

Chemical Oxygen Demand (COD) is an important, rapidly measured variable for the appropriate determination of the organic matter content of water samples. Fig. 5 illustrated the percentage removal of COD versus coagulants; chitosan alone, chitosan-MgO and MgO alone.

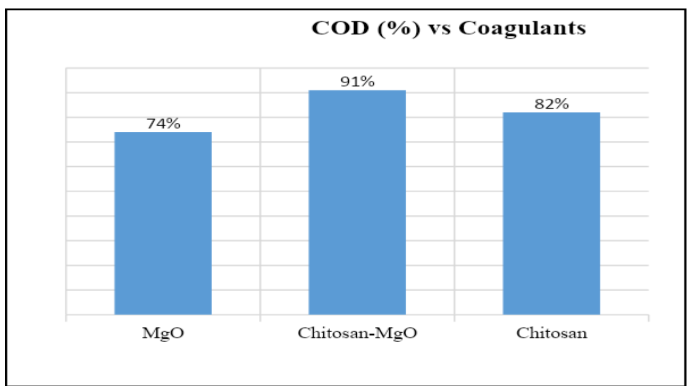


Fig. 5: Effect of coagulants on COD removal

The removal of COD was only 82% by using chitosan as coagulant but when coagulant chitosan coated with MgO was used, the percentage of COD removal can achieve up to 91%. This is because micro particles MgO acted as micro carrier of chitosan where MgO function as adsorbent which increased the adsorption capacity and eventually resulted in rapid adsorption of organic matter present in wastewater thus, reducing the COD level of the wastewater samples [22]. It is very important to reduce the COD level of treated effluent prior to discharge into the natural environment because a higher COD level means a greater amount of oxidised organic materials that could decrease the level of dissolved oxygen (DO) in the water samples. The decrease of DO levels can lead to the anaerobic condition which is highly deleterious for higher forms of aquatic life such as fish and aquatic plants which largely depend on oxygen for respiration and photosynthesis.

In addition, total suspended solids (TSS) are particles that are larger than 2mm found in the water column. The particles with size smaller than 2 mm (average pore size of filter) are considered as a dissolved solid. Most suspended solids are made up of inorganic materials although algae and bacteria can also contribute to the total solids concentration. Fig. 6 demonstrates the TSS removal efficiency in chitosan alone, chitosan-MgO and Mg alone.

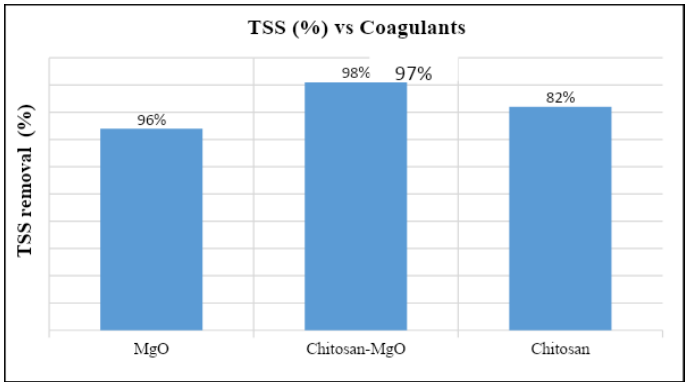


Fig. 6: Effect of coagulants on TSS removal

The suspended solids (SS) removal efficiency for MgO alone, chitosan-MgO and MgO alone were 96%, 98% and 97% respectively. All three coagulants were capable to remove the suspended solids in the turbid water but combination of chitosan-MgO showed the highest removal efficiency compared to chitosan and MgO alone. This is because both chitosan and MgO have good adsorptive ability which makes the combination of them more superior for treating highly turbid water such as river water than any other coagulants [23].

3.4 Optimum Dosage of Chitosan

One of the most important parameters that must be considered to determine the optimum condition for the performance of coagulant in coagulation and flocculation process is dosage [13]. The effect of dosage was analysed at pH 7, rapid mixing for 2 min at 100 rpm and slow mixing for 29 min at 30 rpm and 30 minutes of settling time for a range of coagulant dosage which varied from 0.1, 0.2, 0.3, 0.5, 1.0 mg/L coagulant. The optimum range of dosage of chitosan is at 0.4 mg/L would increase the coagulation performance of chitosan and consequently increase the suspended solids removal [24] . Fig. 7 showed the results of the effects of different dosages of chitosan as coagulant on the removal of turbidity in river water.

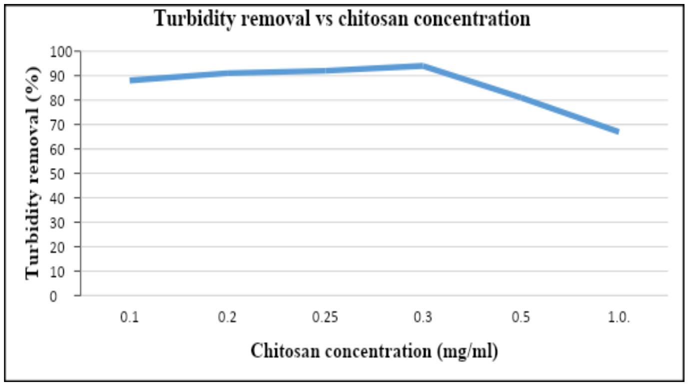


Fig.7: Effect of dosage of chitosan vs turbidity

Fig. 7 present the effect of the chitosan dosage on the coagulation process. From the figure, it could be seen that chitosan produces reduction of turbidity at range 0.25-0.30 mg/mL in 30 minutes of settling time. About 95 % removal of turbidity was achieved at this concentration. All the parameters that were tested was found to follow the allowable limit of both standard A and standard B set by the Department of Environmental (DOE), Malaysia. As a conclusion, MgO coated with chitosan is the best coagulant in this study compared to chitosan and MgO alone because of the ability of treating the river water with up to 90 % removal for all the main parameters.

4. CONCLUSION

MgO coated with chitosan showed better performance of coagulant compared to the chitosan alone and MgO alone. The test to find the optimum dose of chitosan was also conducted in order to improve the effectiveness of chitosan-MgO for further study because the range of 10-30 mg/mL of concentration of chitosan might be suitable for adsorption result but too high for jar test analysis. All the parameters that were tested was found to follow the allowable limit of both standard A and standard B set by the Department of Environmental (DOE), Malaysia. As a conclusion, MgO coated with chitosan is the best coagulant in this study compared to chitosan and MgO alone because of the ability of treating the river water with up to 90 % removal for all the main parameters.

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