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Potential of Modified Orange Peels as Natural Coagulants for Water Turbidity Removal

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Abstract

This research aimed to determine the suitability of aluminium sulfate (alum) and orange peels to act as a chemical coagulants and natural coagulant for water turbidity removal. The performance of these two coagulants was assessed in terms of turbidity removal using jar test experiments for three classes of turbidity. For low turbidity, the results indicated that the optimum dosage and turbidity removal efficiency for aluminium sulfate was found at 54 mg/l with 65.20% efficiency and orange peels was found at 54 mg/l with 81.83% efficiency. For moderate turbidity, the results indicated that the optimum dosage and moderate turbidity removal efficiency for aluminium sulphate was found at 54mg/l with 55% efficiency and orange peels was found at 54 mg/l with 71.04% efficiency. Orange peels showed higher removal efficiency as compared to aluminium sulfate. Last but not least, for high turbidity, the results indicated that the optimum dosage and high turbidity removal efficiency for aluminium sulphate was found at 54mg/l with 64.73% efficiency and orange peels was found at 54 mg/l with 75.47% efficiency. In summary, orange peels showed higher removal efficiency as compared to aluminium sulfate. The study demonstrated that orange peels waste has the potential to be used as a substitute for chemical based coagulant for a future alternative in water treatment.

1. Introduction

The demand for water increased daily due to the growth of the world's population and businesses. However, surface and groundwater intensities declined as a result of overdevelopment, leading to the need for effective techniques to recycle and treat industrial effluent and find substitutes for water sources. The study found industrial pollutants, including organic and biodegradable materials, in the collected lake water, posing a significant risk to the ecosystem. The Malaysian government imposed strict guidelines and restrictions on sewage outflow to protect the environment. The research project developed a simple and reasonably priced water treatment method using orange peels and jar test techniques to reduce the overall cost of the therapeutic setup. The study also computed the consequences of coagulants potion, coagulant particle size, potential of hydrogen, and proximity time on the removal of pollutants in wastewater [1].

The investigation explored the potential of using modified orange peels as a non – chemical coagulant to reduce turbidity in synthetic wastewater, thereby enhancing water quality. The study aimed to determine if modified orange peels could be used as a non-chemical coagulant to eliminate murky conditions in synthetic water. The research involved collecting and processing orange peels to extract coagulating agents, which were then applied to synthetic water samples with known turbidity levels. The water samples were assessed for changes in turbidity, and the efficiency of orange peel-based coagulants compared to conventional chemical coagulants. The study also highlighted the environmental benefits of using modified orange peels as a natural coagulant, as it utilized a waste product that would otherwise be discarded. If successful, this research could have practical applications in water treatment plants, particularly in areas where orange peels are readily available, providing a cost-effective and sustainable solution for water treatment [2].

The issue of water turbidity was a global concern in the age of globalization, primarily caused by human activities such as mining and farming, which produced particles that mixed with water. High turbidity in freshwater bodies of water, such as lakes, rivers, and reservoirs, decreased the amount of light that reached more deeply aquatic plants and organisms, making it harder for fish and shellfish to take in dissolved oxygen (DO) [3].

Turbidity in water is a major concern as it can signal the presence of suspended solids, microorganisms, and other impurities, rendering the water unsafe for consumption and industrial use. While traditional coagulants like aluminum sulfate and ferric chloride are effective, they can have negative environmental and health impacts. Hence, there is a demand for sustainable and eco-friendly coagulants [4].

The investigation explored the potential of orange peel flocculants for water purification, highlighting both the scientific interest and environmental significance of this approach. With growing concerns about water pollution and the need for sustainable treatment methods, the study aimed to develop a deeper comprehension of how orange peel flocculants affect water quality [5].

The study aimed to assess the feasibility of using orange peels as a non – chemical coagulant for addressing water murky state. Orange peels, rich in coagulation properties such as pectin and polyphenols, were considered for their potential to reduce water turbidity. The research involved evaluating the performance of modified orange peels in comparison to traditional chemical coagulants, determining optimal dosage and contact time, and assessing economic and environmental sustainability. The implications of the research were significant, offering a sustainable, eco-friendly, and cost-effective alternative for water turbidity removal, especially in areas with limited access to conventional coagulants. The study also highlighted the potential of utilizing agricultural waste products in water treatment, contributing to a more environmentally responsible approach to water purification [6].

2. Materials and Methods

Orange peels were collected from the store and subjected to multiple washes with tap water to remove clinging dirt. Subsequently, the peels were left to air dry for a duration of 2 hours and manually cut into small pieces using cutters. These pieces were then crushed to obtain a fine powder. The freshly obtained peels were laid out on trays and subjected to oven drying at temperatures ranging from 105°C for a period of 24 hours. Following drying, the peels were powdered and sieved through a 600 μm mesh size. After that, the peel was carefully powdered and kept in an airtight container. Figure 1 below shown orange peels before oven dried and orange peels after oven dried at oven 105°C for 24 hours.

(a) Orange peels before oven dried **(b) Orange peels after oven dried at oven 105° C for 24 hours** **c) Orange peels after blended and sieved through a 600 μm mesh size**

2.2 Methods

2.2.1 Jar Test

Jar tests were carried out to assess the coagulation effectiveness of a natural coagulant. In a conventional jar tester, six 1-liter beakers were filled with 300 ml of a prepared solution containing the necessary turbidity concentration. Orange peel solution, serving as the natural coagulant, was added to each beaker at varying dosages. The mixture was stirred at 140 rpm for 15 minutes for rapid mixing, followed by a reduction in mixing speed to 40 rpm for 30 minutes for slow mixing except in experiments examining the impact a sluggish mixing speed on turbidity elimination efficiency. Subsequently, the stirrer was stopped, and all suspensions were allowed to make do with one hour aside from in experiments exploring the effect of settling period on murky state removal efficiency. Afterward, samples for residual measurement were carefully collected from the top of each beaker, and the turbidity of every sample was measured using a turbidity meter [7].

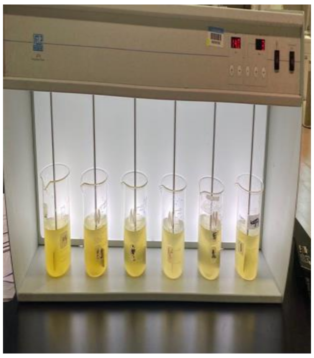

Figure 2 *Jar Test Experiment*

2.3. Equation

Using the formula in Equation 1, turbidity removal was computed in this study to analyze the effectiveness of orange peel powder.

Turbidity Removal Efficiency, TRE (%) =

$$\left(\frac{TO - T}{TO}\right) x\ 100\%\ \ Equation\ 1 \quad (1)$$

$T0$= preliminary measurements of the effluents' turbidity, NTU
T= final measurements of the effluents' turbidity, NTU

3. Results and Discussion

3.1. Effect of initial turbidity on both coagulant performance for low turbidity

Table 1 *Efficiency for pH 6 and 43.1 NTU*

Coagulant	Dosage (mg/l)	Kaolin synthetic wastewater		Kaolin synthetic wastewater		Efficiency of turbidity (%)
		pH	NTU	pH	NTU	
Alum solution	9	6	43.1	6.52	40.1	6.96%
	18			6.66	37.9	12.06%
	27			6.70	30.2	30.16%
	36			6.90	25.2	41.53%
	45			7	17	60.56%
	54			7.11	15	65.20%
Orange peel	9	6	43.1	6.69	27.6	35.96%
	18			6.69	19.4	54.99%
	27			6.70	15.2	64.73%
	36			6.71	11.9	72.39%
	45			6.72	10.3	76.10%
	54			6.73	7.83	81.83%

A graph of dosage of alum and orange peels versus final result after turbidity removal of low turbidity shown in Figure 3. The initial turbidity of 43.1 NTU, which is classified as low turbid water. The results of alum solution after turbidity removal for low turbidity are 40.1 NTU, 37.9 NTU, 30.2 NTU, 25.2 NTU, 17 NTU, and 15 NTU, respectively, is shown by the results. The findings show the results of orange peels solution after turbidity removal for low turbidity are 27.6 NTU, 19.4 NTU, 15.2 NTU, 11.9 NTU, 10.3 NTU, and 7.83 NTU, respectively, experienced a turbidity reduction. It has been demonstrated that the quality of low turbid water can be enhanced by using an orange peel solution compared alum solution.

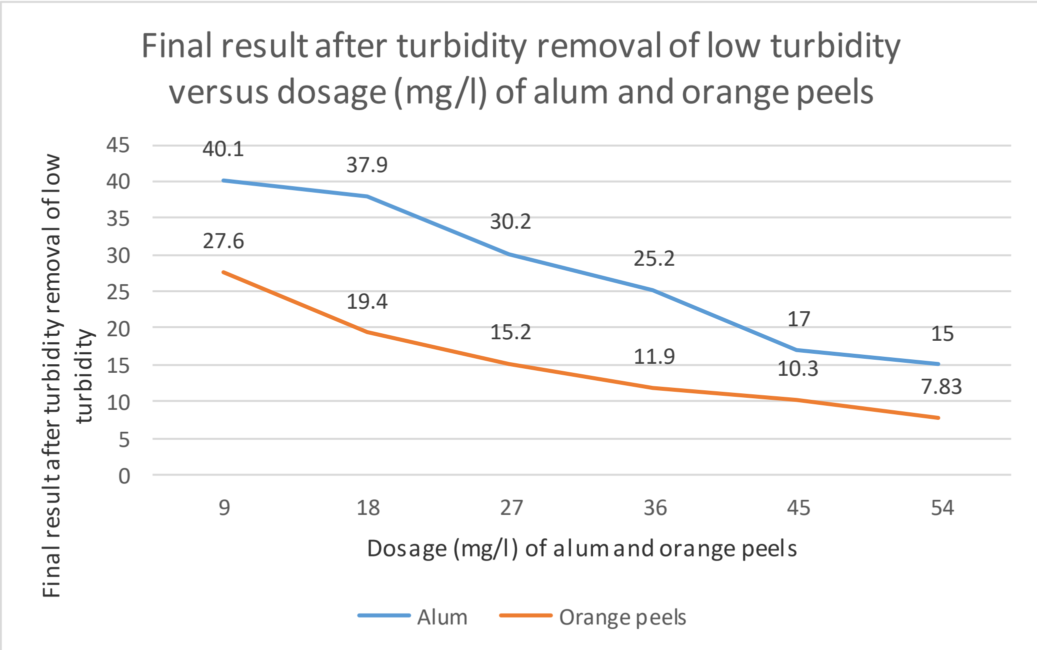

Figure 3 *Final result after turbidity removal of low turbidity versus dosage (mg/l) of alum and orange peels*

3.2. Efficiency on both coagulant performance for low turbidity

A graph of dosage of alum and orange peels versus efficiency of low turbidity (%) shown in Figure 4. The initial turbidity of 43.1 NTU, which is classified as low turbid water. The efficiency of alum solution after turbidity removal for low turbidity are 6.96%, 12.06%, 30.16%, 41.53%, 60.56%, and 65.2%, respectively, is shown by the results. The findings show the efficiency of orange peels are 35.96%, 54.99%, 64.73%, 72.39%, 76.1%, and 81.83% respectively, experienced a turbidity reduction. It has been demonstrated that the quality of low turbid water can be enhanced by using an orange peel solution compared alum solution.

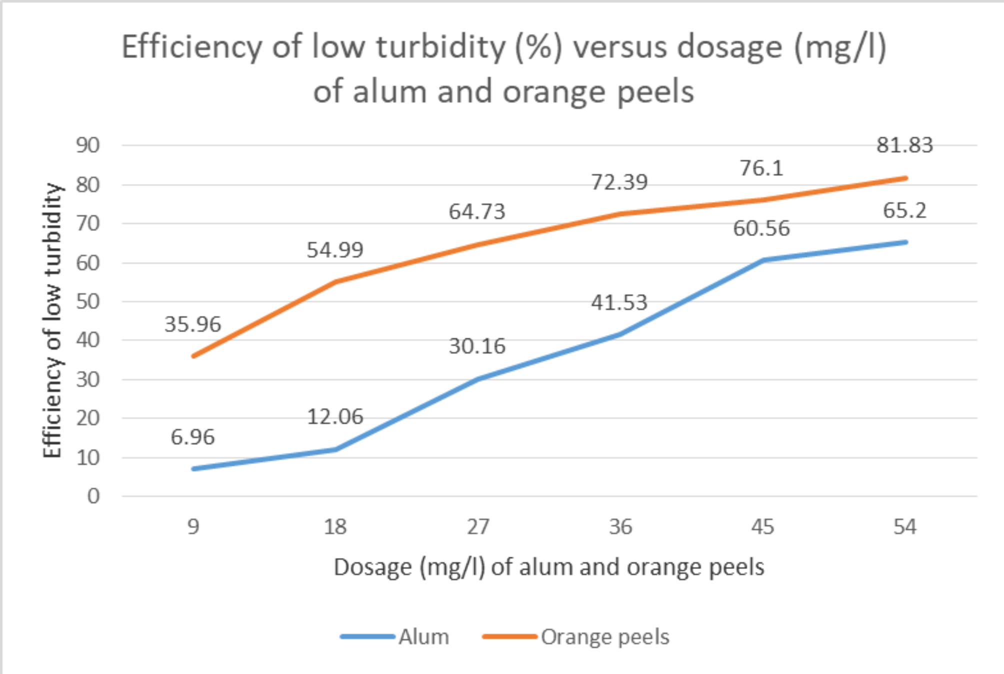

Figure 4 *Efficiency final of low turbidity (%) versus dosage (mg/l) of alum and orange peels*

3.3. Effect of initial turbidity on both coagulant performance for moderate turbidity

Table 2 *Efficiency for pH 6.65 and 96 NTU*

Coagulant	Dosage (mg/l)	Kaolin synthetic wastewater (Initial)		Kaolin synthetic wastewater (After)		Efficiency of turbidity (%)
		pH	NTU	pH	NTU	
Alum solution	9	6.65	96	6.76	93	3.13%
	18			6.94	92.3	3.85%
	27			6.95	79	17.71%
	36			6.96	76.1	20.73%
	45			6.96	75	21.88%
	54			7.14	43.2	55%
Orange peel	9	6.65	96	6.61	83.3	13.23%
	18			6.65	62.6	33.4%
	27			6.66	43.6	34.79%
	36			6.72	43.3	54.90%
	45			6.72	36.8	61.67%
	54			6.76	27.8	71.04%

A graph of dosage of alum and orange peels versus final result after turbidity removal of moderate turbidity shown in Figure 5. The initial turbidity of 96 NTU, which is classified as moderate turbid water. The results of alum solution after turbidity removal for moderate turbidity are 93 NTU, 92.3 NTU, 79 NTU, 76.1 NTU, 75 NTU, and 43.2 NTU, respectively, is shown by the results. The findings show the results of orange peels solution after turbidity removal for moderate turbidity are 83.3 NTU, 62.6 NTU, 43.6 NTU, 43.3 NTU, 36.8 NTU, and 27.8 NTU, respectively, experienced a turbidity reduction. It has been demonstrated that the quality of moderate turbid water can be enhanced by using an orange peel solution compared alum solution.

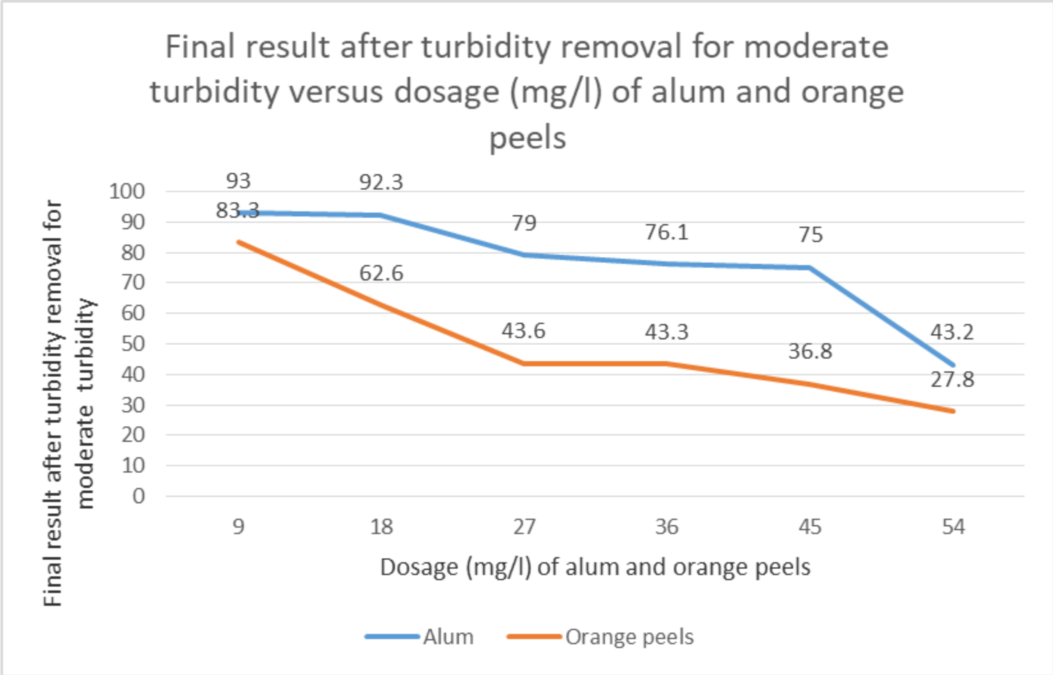

Figure 5 *Final result after turbidity removal of moderate turbidity versus dosage (mg/l) of alum and orange peels*

3.4. Efficiency on both coagulant performance for moderate turbidity

A graph of dosage of alum and orange peels versus efficiency of moderate turbidity (%) shown in Figure 6. The initial turbidity of 96 NTU, which is classified as moderate turbid water. The efficiency of alum solution after turbidity removal for moderate turbidity are 3.13%, 3.85%, 17.71%%, 20.73%, 21.88% and 55%, respectively, is shown by the results. The findings show the efficiency of orange peels are 13.23%, 33.40%, 34.79%, 54.90%, 61.67%, and 71.04% respectively, experienced a turbidity reduction. It has been demonstrated that the quality of moderate turbid water can be enhanced by using an orange peel solution compared alum solution.

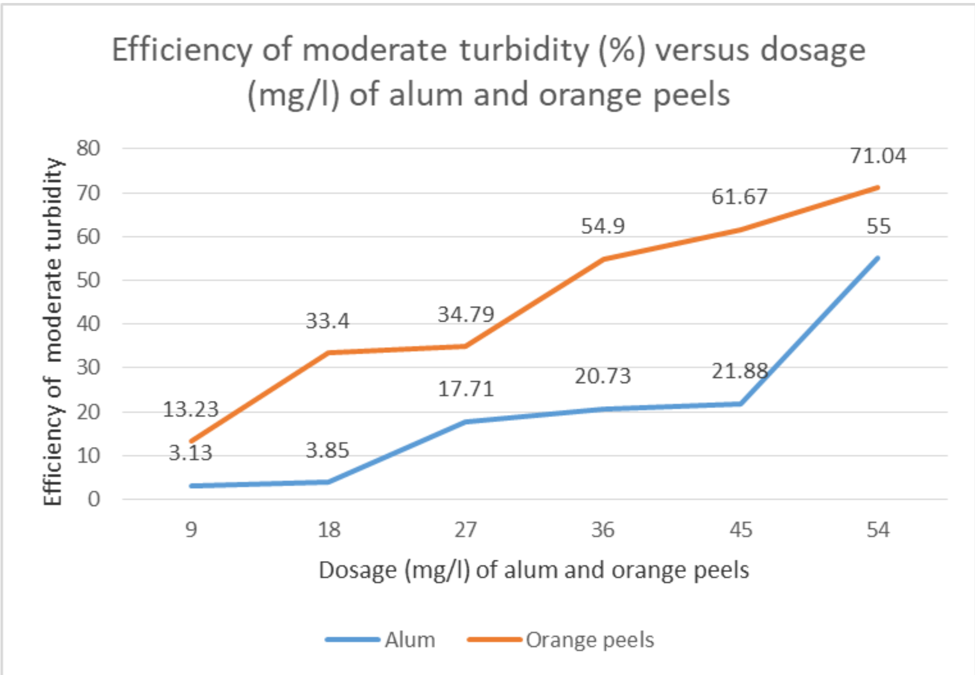

Figure 6 *Efficiency of turbidity versus dosage in grams of alum powder for moderate turbidity*

3.5. Effect of initial turbidity on both coagulant performance for high turbidity

Table 3 *Efficiency for pH 7.35 and 243 NTU*

Coagulant	Dosage (mg/l)	Kaolin synthetic wastewater (Initial)		Kaolin synthetic wastewater (After)		Efficiency of turbidity (%)
		pH	NTU	pH	NTU	
Alum solution	9	7.35	243	7.26	170	30.04%
	18			7.24	150	38.27%
	27			7.23	146	39.92%
	36			7.08	135	44.44%
	45			7.08	100	58.85%
	54			7.05	85.7	64.73%
Orange peel	9	7.35	243	7.35	183	24.69%
	18			7.32	128	47.33%
	27			7.24	96.5	60.29%
	36			7.23	75.2	69.05%
	45			7.19	69.9	71.23%
	54			7.16	59.6	75.47%

A graph of dosage of alum and orange peels versus final result after turbidity removal of high turbidity shown in Figure 7. The initial turbidity of 96 NTU, which is classified as high turbid water. The results of alum solution after turbidity removal for high turbidity are 170 NTU, 150 NTU, 146 NTU, 135 NTU, 100 NTU, and 85.7 NTU, respectively, is shown by the results. The findings show the results of orange peels solution after turbidity removal for high turbidity are 183 NTU, 128 NTU, 96.5 NTU, 75.2 NTU, 69.9 NTU, and 59.6 NTU, respectively, experienced a turbidity reduction. It has been demonstrated that the quality of high turbid water can be enhanced by using an orange peel solution compared alum solution.

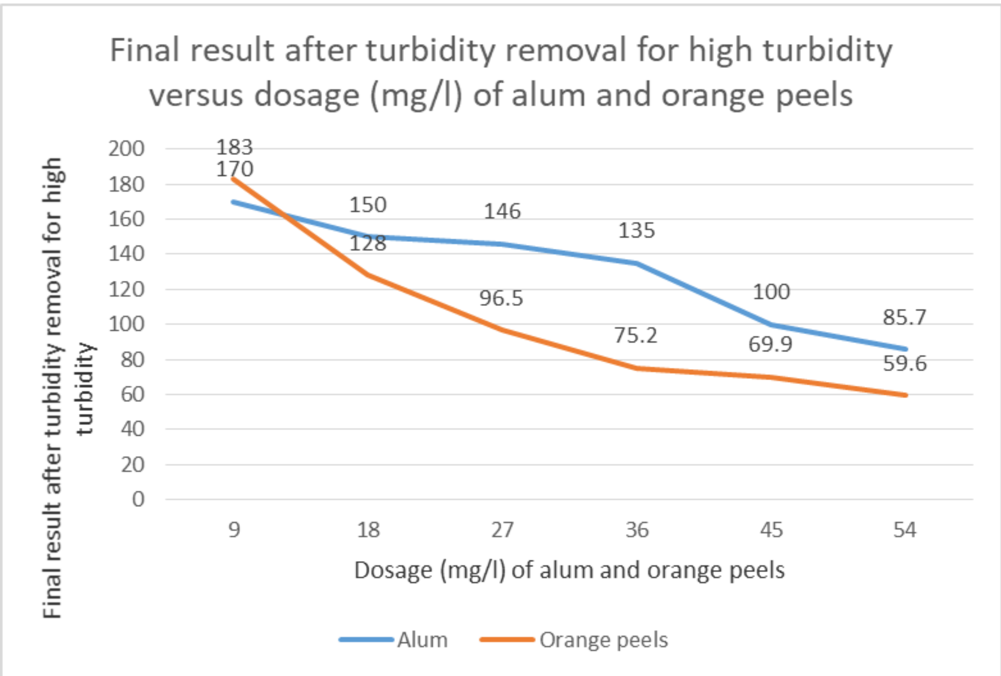

Figure 7 *Final result after turbidity removal of high turbidity versus dosage (mg/l) of alum and orange peels*

3.6. Efficiency on both coagulant performance for high turbidity

A graph of dosage of alum and orange peels versus efficiency of high turbidity (%) shown in Figure 8. The initial turbidity of 243 NTU, which is classified as high turbid water. The efficiency of alum solution after turbidity removal for high turbidity are 30.04%, 38.27%, 39.92%, 44.44%, 58.85% and 64.73%, respectively, is shown by the results. The findings show the efficiency of orange peels are 24.69%, 47.33%, 60.29%, 69.05%, 71.23%, and 75.47% respectively, experienced a turbidity reduction. It has been demonstrated that the quality of high turbid water can be enhanced by using an orange peel solution compared alum solution.

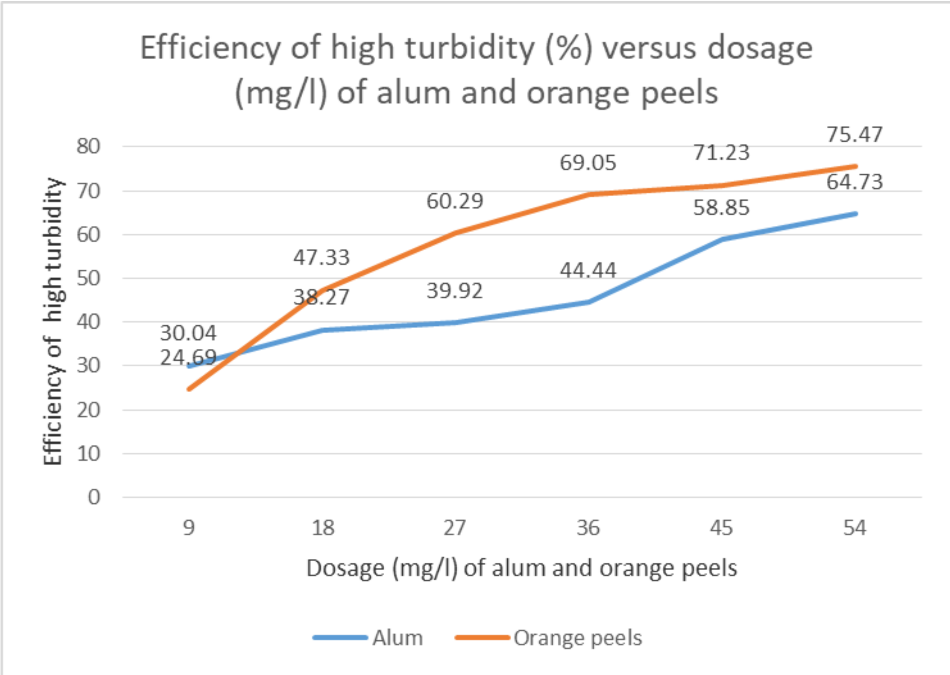

Figure 8 *Efficiency final of high turbidity (%) versus dosage (mg/l) of alum and orange peels*

4. Conclusion

The efficiency of turbidity removal was evaluated between these specified parameters, and the best values for each investigated parameter were found. Orange peels powder dose of 54 mg/l and the mixture was stirred at 140 rpm for 15 minutes for rapid mixing, followed by a reduction in mixing speed to 40 rpm for 30 minutes for slow mixing are the ideal time. Orange peels powder produced the highest efficient turbidity reduction percentages of 35.96%% and 81.83%, respectively, under these circumstances. As a result, it can be inferred that orange peels powder can be utilized as a natural coagulant alternative to synthetic coagulants such as alum, which is widely employed in numerous sectors but has significant environmental and human health consequences.

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Journal

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