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Post-Treatment Of Anaerobically Treated Domestic Sewage Using Coagulation: A Jar Test Approach

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ABSTRACT
This study investigates the suitability of coagulation and flocculation processes as an advanced treatment technique for the effluent discharged from Upflow Anaerobic Sludge Blanket (UASB) reactors, which are commonly utilized in the treatment of domestic sewage. The research aims to improve the quality of wastewater treated anaerobically by further reducing organic load and nutrient concentrations. To determine the effectiveness of the treatment, standard jar tests were conducted using two widely adopted chemical coagulants: Aluminium Sulfate (commonly known as Alum) and Polyaluminium Chloride (PAC). The purpose of these tests was to identify the most effective dosage for maximum contaminant removal. Results from the experiment indicated that the optimal dosages for achieving significant pollutant reduction were approximately 500 mg/L for Alum and 600 mg/L for PAC. Both coagulants demonstrated notable efficiency in reducing parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), and nutrients including nitrogen and phosphorus. The performance of the coagulation process exceeded that of aeration, particularly in removing phosphorus and nitrogen, where reductions up to 92% and 85% were achieved respectively. Furthermore, coagulation proved highly effective in the removal of pathogenic organisms, achieving up to 99% elimination. Based on these findings, it is concluded that coagulation, particularly using Alum and PAC, is a promising option for the post-treatment of UASB reactor effluent, offering an enhanced level of treatment that meets environmental discharge standards.

Keywords: *UASB; Coagulation; Alum; PACL; Post treatment; Aeration.*

INTRODUCTION

In the current era of rapid urbanization and industrial expansion, the management of wastewater has become a crucial aspect of environmental engineering. One of the widely accepted and cost-effective biological treatment technologies for handling domestic and industrial sewage in developing countries is the Upflow Anaerobic Sludge Blanket (UASB) reactor [1]. These reactors operate under anaerobic conditions and are designed to convert organic matter into biogas [2], primarily methane, which can be used as an energy source. The major advantages of UASB systems include low energy requirements, simple design, reduced sludge generation, and the potential for resource recovery such as nutrients and energy.

Despite their efficiency in treating wastewater, UASB reactors alone may not be sufficient to meet the increasingly stringent effluent discharge standards [3] imposed by environmental regulatory agencies. The effluent leaving the reactor typically contains residual organic matter, nutrients such as nitrogen and phosphorus [4], and pathogens that can pose a threat to public health and aquatic ecosystems if discharged untreated. Therefore, a secondary or post-treatment process is often necessary to further polish the effluent and bring the water quality within acceptable limits for either discharge or reuse.

Post-treatment options can vary depending on the nature of the wastewater and local environmental requirements. Traditional methods like aerobic treatment, filtration, constructed wetlands, and advanced oxidation processes [5] are commonly employed. However, physical-chemical methods such as coagulation and flocculation offer a rapid and efficient alternative [6], especially in cases where space, cost, or operational simplicity is a concern.

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The treatment of domestic sewage is critical for protecting public health and the environment, particularly in areas facing water scarcity or limited wastewater infrastructure [7,8]. Anaerobic treatment processes, such as Upflow Anaerobic Sludge Blanket (UASB) reactors, have gained popularity in developing countries due to their low energy requirements and ability to produce biogas [9,10]. However, while effective at reducing organic loads, anaerobically treated effluents often still contain significant amounts of suspended solids, pathogens, nutrients, and turbidity, necessitating further post-treatment before safe discharge or reuse [11].

Coagulation is a widely used physico-chemical method for enhancing the removal of residual contaminants from wastewater [12]. By destabilizing colloidal particles and facilitating their aggregation into larger flocs, coagulation can significantly improve the clarity and quality of treated water. The effectiveness of this process depends on various factors, including the type and dosage of coagulant, mixing conditions, pH, and the characteristics of the wastewater [13].

In particular, coagulation involves the addition of chemicals that destabilize suspended and colloidal particles, allowing them to aggregate and settle out of the water [14,15]. Common coagulants include Alum and Polyaluminium Chloride (PAC) both of which have been extensively studied for their effectiveness in removing a wide range of pollutants, including turbidity, organic load, nutrients, and pathogens [16,17]. The jar test is a standard laboratory procedure used to simulate and optimize the coagulation process under controlled conditions. It enables the systematic evaluation of different coagulants and dosages to identify the most effective treatment configuration for specific wastewater characteristics [18,19].

This research focuses on evaluating the potential of coagulation as a post-treatment method for UASB reactor effluent. It compares the treatment efficiency of Alum and PAC and examines their impact on various water quality parameters. Additionally, it contrasts the performance of coagulation with conventional aeration-based treatment processes to determine the most effective and practical solution for improving effluent quality.

By addressing the limitations of anaerobic treatment through a cost-effective and scalable post-treatment approach, this study contributes to the development of integrated wastewater management strategies that are both sustainable and compliant with environmental regulations [20,21].

MATERIALS AND METHODOLOGY

This investigation was conducted at the Upflow Anaerobic Sludge Blanket (UASB) treatment plant located in Bamroli, a region within the city of Surat, Gujarat, India. The study focused on evaluating the effectiveness of chemical coagulation as a tertiary treatment process, specifically targeting the enhancement of effluent quality post anaerobic digestion [17, 18].

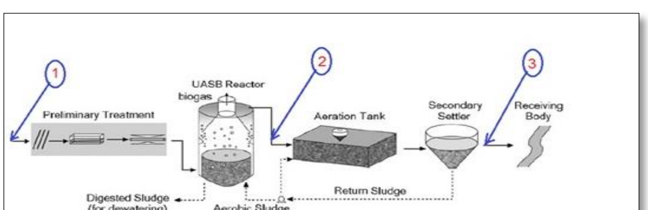

Figure1. Sampling point of study

The samples were analysed for pH, Solids, BOD, COD, Nitrogen, Phosphorous, and Coliform in the laboratory. This study is about the post treatment of UASB effluent using coagulation so Jar tests was carried out to determine optimum coagulant dose for post treatment of UASB effluent.The coagulants used in this study were Alum and Poly Aluminium chloride (PACl). Turbidity was measured of each sample after allow to settle for enough time. Then from

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the reading of the turbidity the optimum dose of the Alum and Poly Aluminium chloride (PACl) were decided. The remaining treated samples were then analyzed for pH, Solids, BOD, COD, Nitrogen, Phosphorous, and Coliform in the laboratory.

RESULT AND DISCUSSION

Jar test was performed to determine the optimum dose of coagulant.

Table 1: Determination of optimum dose of coagulant

Dose (mg/lit)	Turbidity in NTU (Alum)		Turbidity in NTU (PACl)	
	Test-1	**Test-2**	**Test-1**	**Test-2**
0	148	498	150	458
10	90	452	101	370
20	50	436	63	239
50	19	324	29	167
100	10	235	17	124
250	9	102	5	89
350	6	57	4	10
500	5	6	4	7
650	5	8	2	5
800	4	7	3	6
1000	-	6	-	3
1200	-	5	-	2

Turbidity readings which are highlighted indicating maximum dose require for post treatment. Then these treated samples were analyzed for Solids, BOD, COD, Nitrogen, Phosphorous, and Coliform in the laboratory.

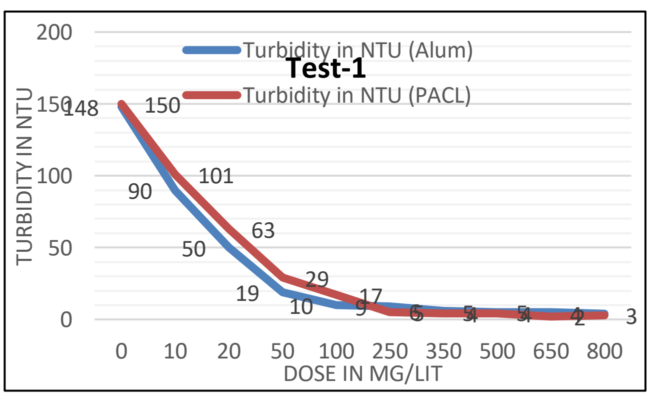

Figure 2. Reduction of turbidity in test

Table 2: Reduction by PACL of UASB Effluent

Parameters		UASB Outlet	PACl	Effluent of SST

				% removal		% removal
TSS (mg/lit)	Test-1	585	242	58.63	480	17.95
	Test-2	700	149	78.71	600	14.29
TDS (mg/lit)	Test-1	560	217	61.25	510	8.93
	Test-2	630	234	62.86	490	22.22
TS (mg/lit)	Test-1	1145	459	59.91	990	13.54
	Test-2	1330	383	71.2	1090	18.05
COD (mg/lit)	Test-1	210	89	57.619	176	16.19
	Test-2	340	80	76.47	168	50.588
BOD (mg/lit)	Test-1	108	76	29.629	94	12.962
	Test-2	138	74	46.376	114	17.391
PO_4^{-3} (mg/lit)	Test-1	2.9	0.21	92.76	1.46	49.66
	Test-2	4	0.52	87	2	50
Nitrogen (mg/lit)	Test-1	26.6	3.36	87.37	12.6	52.63
	Test-2	37	5.74	84.49	16.8	54.59
Coliform	Test-1	93000	28	99.97	-	
	Test-2	360000	38	99.99	-	

Table 3: Reduction by ALUM of UASB Effluent

Parameters		UASB Outlet	Alum		Effluent of SST	
				% removal		% removal
TSS (mg/lit)	Test-1	585	142	75.73	480	17.95
	Test-2	700	190	72.86	600	14.29
TDS (mg/lit)	Test-1	560	258	53.93	510	8.93
	Test-2	630	297	52.86	490	22.22
TS (mg/lit)	Test-1	1145	400	65.07	990	13.54
	Test-2	1330	487	63.38	1090	18.05
COD (mg/lit)	Test-1	210	106	49.52	176	16.19
	Test-2	340	120	64.705	168	50.588
BOD (mg/lit)	Test-1	108	82	24.074	94	12.962
	Test-2	138	92	33.333	114	17.391
PO_4^{-3} (mg/lit)	Test-1	2.9	0.38	86.9	1.46	49.66
	Test-2	4	0.41	89.75	2	50
Nitrogen (mg/lit)	Test-1	26.6	4.06	84.74	12.6	52.63
	Test-2	37	7.98	78.43	16.8	54.59
Coliform	Test-1	93000	43	99.95	-	
	Test-2	360000	93	99.97	-	-

Table 2 and 3 showing summery of whole results and comparison between quality of effluent of aeration tank and sample which was treated with coagulation. It is observed that by coagulation (Alum and PACL) we can reduce TS, TDS and TSS up to 75%, 50-55% and 65-63% respectively. But in case of aeration followed by SST we can achieve reduction up to 15-20% only. It is observed that by coagulation Phosphorous and Nitrogen can be reduced up to 85-92 % and 75-85% respectively and it is far better than 55% reduction achieved by Aeration. we can reduce COD and BOD up to 75 % and 45 % respectively, But by using aeration only 20 to 50 % reduction in COD and BOD.

Table 4: Comparison percentage reduction of coagulants

Parameter	ALUM	PACL	Post treatment of plant
Phosphorous %	88.33	89.78	49.83
Nitrogen %	81.58	85.93	53.61
COD %	57.11	67.04	50.389
BOD %	28.7	38	15.17
E-Coli %	99.96	96.13	0
TS %	62.41	64.13	13.38
TDS %	53.39	62.05	18.75
TSS %	71.42	66.36	16.12

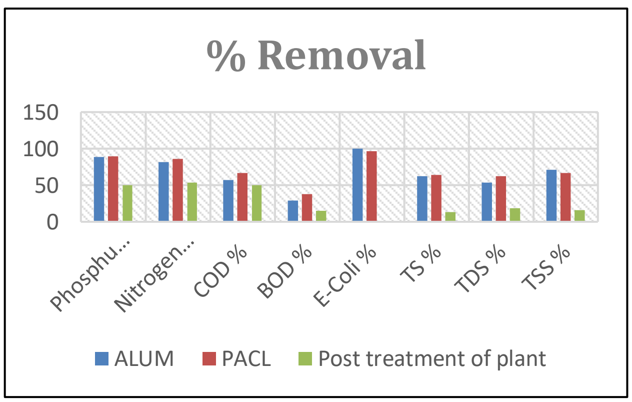

Figure 3. Comparison in reduction efficiency of Alumn PACL and Aeration.

From Fig. 3 It is clear that coagulation is better option for post treatment of UASB effluent camper to Aeration because average percentage reduction by aeration is less in all of the parameters.

CONCLUSIONS

The optimum chemical dosage was 500 mg/L to 600Mg/L for [alum, polyaluminium chloride (PAC)] respectively. It was found that both tested coagulants were effective in reducing the effluent BOD, COD, TS, TDS, TSS. Coagulation treatment is also efficient in reduction of nutrient from wastewater because by coagulation we can reduce Phosphorous and Nitrogen up to 85-92 % and 75-85% respectively. There was excellent removal of bacteria by coagulation Alum and PACl and it was almost 99%. Overall, the combination of anaerobic digestion and coagulation has proven to be a very efficient method for wastewater treatment achieving final COD concentrations lower than 100 mg/L. so coagulation is a good option for post treatment of UASB effluent.

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