"EXPERIMENTAL STUDIES FOR DETERMINATION OF THE OPTIMUM DOSE OF COAGULANTS FOR TREATMENT OF WASTE WATER"

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Abstract – *Different types of coagulants are available in market for treatment of waste water, but determination of optimum dose of particular coagulant depending upon characteristics of waste water is a challenge. This study is based on determination of the optimum dose of coagulant for treatment of waste water. Here waste water is collected from two different sources; one is domestic sewage water, second one is industrial waste water. After the collection of waste water samples, their basic physical and chemical parameters are tested, like pH, Color, Odor, Temperature, Conductivity, DO and TSS. After the primary tests, Jar test is performed using different coagulants (Alum, $Fecl_3$) at a varying dose. It has been observed that sufficient reduction of Turbidity and the BOD (Biochemical Oxygen Demand) has taken place at particular dose of coagulant in waste water sample. Based on the experimental results we can easily conclude that which coagulant along with its optimum dose is suitable for waste water treatment. The doses of coagulants obtained in our work are sufficient for in-situ waste water treatment.*

Key Words: Optimum dose, Waste water treatment, Coagulants, BOD, Turbidity, Jar test

1. INTRODUCTION

1.1 General

Now a days we are facing many problems related to the water or facing the shortage of water for Drinking purpose, Irrigation purpose, Industrial uses and other domestic usage.

We are also suffering from various diseases because of the polluted water. The land is also polluted by the outlet of the industrial waste water. The industries also discharge their waste water into river or land without treatment. The domestic sewage water is also directly discharge into the river. Because of that; the pure water may also get polluted. So we decided to treat the waste water before discharge into the river or on the land. We just use some chemical compounds or metallic salts to treat the waste water.

Waste water has three types of impurities. (1) Suspended (2) Colloidal (3) Dissolved. Most of suspended particles can be easily removed by the filtration process. But plain sedimentation will not be efficient for smaller suspended particles and colloids.

When we add coagulants to the waste water; particles having negative charge gets neutralized in contact with coagulant which reduces the zeta-potential of particles in water sample. After that, because of the high density and weight, the impurities settle down with the coagulants at the bottom of the jar (or at the bottom of the tank in case of mass treatment of waste water). Addition of coagulants lowers the turbidity and helps to treat the waste water. After that we can easily remove the flocs by filtration process.

Suggestions will provide to industries manager and sewer supervisor to apply this to the industry outlet, sewage outlet. So we can minimize the water containing the waste and prevent the water pollution.

1.2 What is coagulant?

Coagulants can also be described as metallic salts.

A coagulant with the opposite charge is added to the water to overcome the repulsive charge and "destabilize" the suspension. For example, the colloidal particles are negatively charged and alum is added as a coagulant to create positively charged ions.

In a colloidal suspension, particles will settle very slowly or not at all because the colloidal particles carry surface electrical charges that mutually repel each other. Once the repulsive charges have been neutralized, the 'Van der Waals' force will cause the particles to cling together and form micro flocs.
Coagulants used in general: Alum, Aluminium Chloride, Aluminium Sulphate, Aluminium Chlorohydrate, Ferric Chloride, Ferrous Sulphate Monohydrate, Polyaluminium Chloride (PAC), Polyaluminium Hydroxychloride, Bentonite Clay, Poly Clay 104 etc.

1.3 What is optimum dose?

The quantity of chemical substance which can produce the desire effects without any unfavorable effect. We can also say that the optimum dose is the minimum dose of coagulant required for waste water treatment.

For this experiment we have to define optimum dose of coagulants according to the type of waste water. For various doses we have to perform the jar test and decide the suitable dose for treatment which gives us the best result.

1.4 Coagulation process

Very fine suspended clay particles and colloidal matter present in water cannot be removed by plain sedimentation. If we want to remove such particles by plain sedimentation detention time would be very long which is not practically feasible.

They can however be removed easily by increasing their size by changing them into flocculated particles. For this purpose, certain chemical compounds (coagulants) added to the water which on through mixing, form a gelatinous precipitate called 'floc'. The very fine colloidal particles present in water, get attracted and absorbed is these flocs, forming the bigger size flocculated particles.

Coagulant chemicals with charges opposite those of the suspended solids are added to the water to neutralize the negative charges on non-settable solids (such as clay and color-producing organic substances). Once the charge is neutralized, the small suspended particles are capable of sticking together. These slightly larger particles are called microflocs, and are not visible to the naked eye. Water surrounding the newly formed microflocs should be clear. If not, coagulation and some of the particles charge have not been neutralized. More coagulant chemicals may need to be added.

A high-energy, rapid-mix to properly disperse coagulant and promote particle collisions is needed to achieve good coagulation. Over-mixing does not affect coagulation, but insufficient mixing will leave this step incomplete.

Coagulation process also helps in removing color. The coagulation is to be adopted when turbidity of water exceeds 30 to 50 mg/lit.

For example:

$$Fe2(SO4)_3 + 3Ca(HCO_3)_2 \rightarrow 2Fe(OH)_{3\,(S)} + 3CaSO_4 + 6CO_{2\,(g)}$$

$$Al_2(SO_4)_3 * 14H_2O + 6HCO_3 \rightarrow 2Al(OH)_{3\,(S)} + 6CO_2 + 14H_2O + 3SO_4^{-2}$$

2. LITERATURE REVIEW

2.1 Chemical waste water treatment method:

Patent (US4049545A)

A method of treating domestic, commercial or industrial waste water which includes the steps of mixing the waste water with a coagulant aid so as to bring the pH of the mixture to within a range of about 9.0-10.5, and thereafter adding precipitating agents in at least two successive steps so as to lower the pH of the mixture by about one unit for each step and thereby precipitate solids therefrom until the mixture is approximately neutral. After the addition of each precipitating agent, the precipitated solids are separated from the waste water effluent before the next succeeding precipitating agent is added. Preferably two such successive precipitation steps are performed, after which the resultant waste water effluent is treated with an oxidizing and disinfecting agent, filtered, and then treated with a further oxidizing and disinfecting agent to minimize the B.O.D. level. In the course of the process, a portion of the solids separated from the waste water effluent in the respective steps is preferably recycled into the treatment system by mixing it with new incoming waste water to partially take the place of the original coagulant aid. The preferred coagulant aid utilized is Portland cement, with aluminum sulfate and copper sulfate preferably being used in sequence as the precipitating agents and potassium permanganate and ozone being used in sequence as the oxidizing and disinfecting agents.

2.2 Compound coagulant for waste water treatment and its usage

Patent (CN1227192A)

The compound coagulant for treating waste water consists of soluble compounds of Fe, Ca, Mg, Al, etc., such as ferrous sulfate, calcium oxide, magnesium chloride, aluminum sulfate, etc., and difficultly soluble aluminosilicates including bentonite, Kaolin, diatomite, slag, etc. When used in acid condition, the compound coagulant is added into waste water before the pH value of the wastewater is regulated with alkali solution to 7-9, so that the organic matters in the waste water is ion-adsorbed by the compound coagulant.

The compound coagulant may be also used directly in neutral or alkali conditions. The present invention has high waste water treating effect.

3. METHODOLOGY

Waste water collection: First water sample is collected from, sewage line near Visnagar, Mehsana, Guarat. Second, Industrial waste water is collected from the industry which makes Medical Bandages near Mahadevpura, Vijapur, Gujarat.

Check for Physical and Chemical Parameters: Checked physical parameters, which are Color, Odor, Temperature, Conductivity and chemical parameters, which are pH, DO and BOD are done as per standard methods.

Addition of Coagulants: Doses of coagulants are varied in ascending order for six number of jar. The concentration of coagulant is in ppm or mg/lit.

Jar Test: The jar test was performed using a series of six glass containers of 1 Liter capacity, uniform size and shape. These jars were used with stirring device that simultaneously mixes the contents of each jar with a uniform power input. Each jar was filled with raw waste water. One jar was used as control, while the remaining five were dosed with different amounts of coagulants. After the coagulants were added, the waste water was mixed rapidly for 2 minutes (at about 100 rpm) to ensure complete dispersion of the chemicals, and then waste water was mixed slowly for 10 minutes to aid in the formation of flocs. The water was next allowed to settle for 45 minutes, or until clarification had occurred.

Final DO: By Winkler's method DO of both the water samples are find out. By the values of DO for raw waste water and value of DO for same sample which was put for BOD in Incubator. The formula for determination of value of BOD is:

$$BOD = \frac{\text{Initial DO value of sample}(D_1) - \text{DO value at the end of 5 days incubation}(D_2)}{\text{decimal volumetric fraction of sample used}(P)}$$

D_1 = Dissolved oxygen value of raw water
D_2 = Dissolved oxygen value of treated sample
P = Volume of sample diluted by total volume of water take for dilatation (if 25 ml sample diluted in 300 ml then P= 25/300 = 0.0833)

4. RESULTS

4.1 Basic Parameters:

Physical and Chemical Parameters	Sewage waste water	Industrial waste water
pH	7.01	6.76
Colour	Yellowish grey	Light yellow
Odour	Oily smell	Phenolic smell
Temperature	32° C	30° C
Conductivity	2.37 ms	7.67 ms
DO	4 mg/lit	5.5 mg/lit
Initial Turbidity	57.8 NTU	98.67 NTU
Initial BOD	24 ppm	24.081 ppm
TSS	0.12 mg/lit	0.42 mg/lit

4.2 For Treatment of Sewage waste water:

Dose of coagulants and Turbidity removal:

Coagulants	Jar	Initial turbidity (NTU)	Dose of Alum	Final turbidity (NTU)	%removal of turbidity
Alum $Al(SO_4)_2$	Jar-1	96.8	0 ppm	80.72	16.61%
	Jar-2	100.3	5 ppm	21.70	78.36%
	Jar-3	100.2	10 ppm	9.60	90.42%
	Jar-4	96.0	15 ppm	4.30	95.52%
	Jar-5	**96.6**	**20 ppm**	**3.80**	**96.14%**
	Jar-6	96.4	25 ppm	7.40	92.36%
$FeCl_3$	Jar-1	9.2	0 ppm	7.2	21.71%
	Jar-2	13.0	10 ppm	8.7	33.07%
	Jar-3	10.5	20 ppm	10.3	19.05%
	Jar-4	21.8	30 ppm	9.2	57.80%
	Jar-5	**26.4**	**40 ppm**	**9.01**	**65.90%**
	Jar-6	23.8	50 ppm	9.1	61.76%

Percentage of BOD and Turbidity removal:
(Treatment with Alum)

Parameters	With Alum (Dose 20 ppm)		
	Initial	**Final**	**% Removal**
Turbidity	14.70 NTU	3.80 NTU	96.14%
BOD (5 days)	15.606 ppm	9.600 ppm	38.48%

(Treatment with $FeCl_3$)

Parameters	With $Fecl_3$ (Dose 40 ppm)		
	Initial	**Final**	**% Removal**
Turbidity	26.40 NTU	9.01 NTU	65.90%
BOD (5 days)	32.410 ppm	20.410 ppm	37.02%

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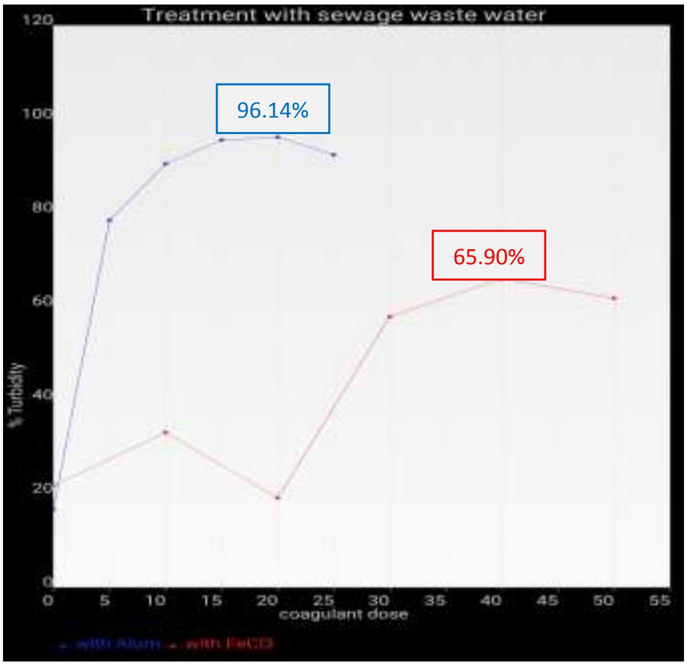

Chart -1: Graph of Turbidity removal (for sewage water)

4.3 For Treatment of Industrial waste water:

Dose of coagulants and Turbidity removal:

	Jar	Initial Turbidity (NTU)	Dose of Alum	Final Turbidity (NTU)	%removal of turbidity
Alum $Al(SO_4)_2$	Jar-1	16.0	0 ppm	13.10	22.13%
	Jar-2	16.9	5 ppm	13.40	20.71%
	Jar-3	22.6	10 ppm	8.80	61.06%
	Jar-4	16.7	15 ppm	8.20	50.89%
	Jar-5	16.0	20 ppm	14.40	10.38%
	Jar-6	15.5	25 ppm	10.90	30.12%
$FeCl_3$	Jar-1	193.3	0 ppm	62.1	67.87%
	Jar-2	191.0	10 ppm	56.8	70.26%
	Jar-3	172.2	20 ppm	55.1	68.01%
	Jar-4	179.0	30 ppm	56.2	68.60%
	Jar-5	167.5	40 ppm	58.3	65.19%
	Jar-6	178.5	50 ppm	51.3	71.20%

Percentage of BOD and Turbidity removal

(Treatment with Alum)

Parameters	With Alum (Dose 10 ppm)		
	Initial	Final	% Removal
Turbidity	21.60 NTU	8.80 NTU	61.06%
BOD (5 days)	30.012 ppm	21.248 ppm	29.20%

(Treatment with $FeCl_3$)

Parameters	With $Fecl_3$ (Dose 50 ppm)		
	Initial	Final	% Removal
Turbidity	178.5 NTU	51.3 NTU	71.26%
BOD (5 days)	18.150 ppm	7.220 ppm	60.22%

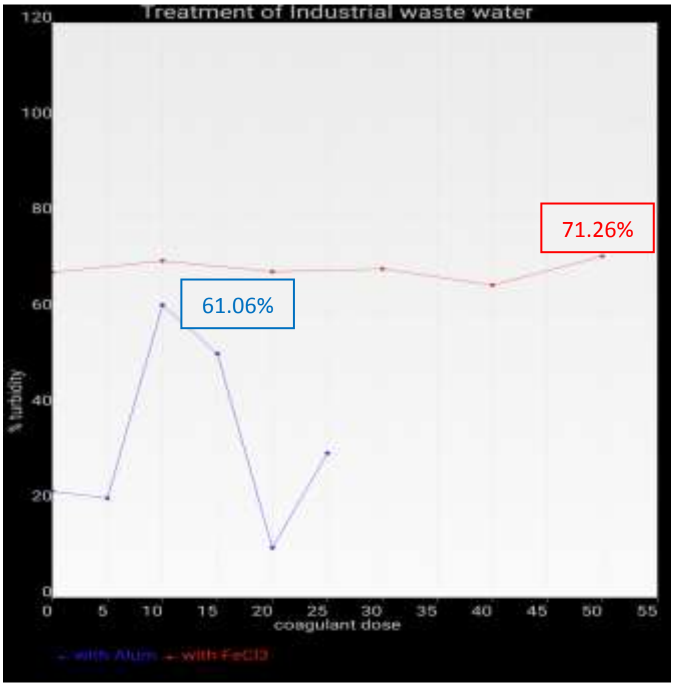

Chart -2: Graph of Turbidity removal (for Industrial water)

5. CONCLUSIONS

5.1 For Sewage waste water

After the calculation of Turbidity and BOD for domestic sewage water; we can see that the percentage removal of turbidity is around 96 % by 20 ppm dose of Alum.

For the same sample, we see that the percentage removal of turbidity is only around 65 % by 40 ppm dose of $FeCl_3$.

We also calculated for the BOD removal and it's around 38% removal by 20 ppm dose of Alum. And 37% removal by 40 ppm dose of $FeCl_3$. '

So from this we can say that the Alum is good for the treatment of sewage water and the 20 ppm is our optimum dose.

5.2 For Industrial waste water

After the calculation of Turbidity and BOD for industrial waste water; we can see that the percentage removal of turbidity is only 61% by the 10 ppm dose of Alum. But for

the same sample we got 71% of turbidity removal by 50 ppm dose of $FeCl_3$.
We also calculated for the BOD removal and it's just 30% removal by 10 ppm dose of Alum. But we got 60% BOD removal by 50 ppm dose of $FeCl_3$.
So, we can say that the $FeCl_3$ is suitable for the treatment of industrial waste water and 50 ppm is our optimum dose.

* Work Gallery:

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