Research Article

A Study of the Influence of Water Treatment Plant Sludge on Waste Water Treatment

V. Gopalakrishnan[1*], R. Velkennedy[2]
Research Scholar, Noorul Islam University, Kumaracoil, Tamil Nadu, India.
Associate Professor, Dept of Civil Engineering, Thiyagarajar College of Engineering, Madurai, India.
***Corresponding author's E-mail:** umagopal65@gmail.com

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ABSTRACT

When alum is used as a coagulant in a water treatment plant (WTP) and lime is used to balance the p^H value, a large volume of sludge is generated. The characteristics of the generated sludge depend strongly on the water source and the quality and quantity of the chemicals used for the treatment process. Disposal of this sludge is a major challenge faced by WTPs around the world. In this paper an attempt has been made to study the feasibility of WTP sludge to treat the municipal waste water in the preliminary stage before going for biological treatment. The scope of the study are (1) The quantity of COD, suspended solids and p^H value in the treated water will be studied (2) The reactiveness of WTP sludge with the waste water will be studied by varying the speed of flocculator paddles. The WTP sludge will be applied with municipal sewage to a series of jar tests conducted under various operating conditions. It is observed that the BOD, COD, TSS values of the sewage is considerably reduced while adding the WTP sludge and the removal efficiency is mainly depending upon the dosage of the WTP sludge, optimum p^H condition and operating speed of the paddle.

Keywords: WTP sludge, waste water treatment, jar test, TSS,COD, BOD, reuse.

INTRODUCTION

Large number of water treatment plants with conventional treatment method is being executed for the community to provide safe and portable drinking water to the people. Environmental awareness among people give pressure on the water production industries for safe disposal techniques for the sludge generated in water treatment plants (WTP). Chemicals are used as coagulants for the removal of impurities in WTP[3]. Alum is widely used as a coagulant due to reasonable cost and availability. For effective functioning of Alum as a coagulant, lime is also used in WTP to maintain a standard pH value.

Hence Alum sludge and Lime sludge remains the by product of the water treatment plant. Every year a huge volume of WTP sludge is produced, which gives considerable concern over its disposal. Mostly all the WTPS are discharging their sludge with huge volumes of water directly into nearby water bodies[1]. It leads the quality deterioration and accumulatively rise the aluminium concentration in water. This chain process is continued till the conflux point of the water body or river. On the other hand, while disposing into the ponds, the aquatic organisms are consuming the alum contaminants. In turn, it affects the human being which is linked to occurrence of Alzheimer disease. To over come the above problems the WTP sludge has to be utilized in a effective manner. On the other hand the limited availability of land and the possibility of polluting the land with excess chemicals implied restriction to the agencies to dispose the WTP sludge on the land. Potentially, some part of the sludge could be reused on pretreatment of municipal waste water treatment process. In a waste water treatment system, the removal efficiencies of Total dissolved solids (TSS), Chemical oxygen demand (COD), and Biological oxygen demand (BOD) are around 50%, 30% and 25% respectively by the primary treatment system. Such low removal efficiencies are mainly due to the insufficient removal of micro suspended particles. Removal of small particles which is less than 50µm is almost impossible by conventional settling tank[4].

Thus to improve the removal efficiency of TSS, COD and BOD from municipal sewage in primary treatment through chemical coagulation and flocculation is necessary.

Since the WTP sludge contains a large portion of Aluminium hydroxide that can be utilized as a coagulant to reduce the TSS.

Literature Review

Chu has made a study on the lead metal removal by recycled alum sludge[6]. Huang explained the reuse of water treatment plant sludge and dam sediments in brick making[8].

The study revealed that the mixtures of WTP sludge and dam sediments by maintaining a temperature of 1000oC and 1100°C for 24 hours to attain the required properties for the tiled brick.

Timothy have studied the characterization of Drinking water sludge for beneficial reuse and Disposal[7].

Wilson have made a study on the reuse option of Water Treatment Plant sludge as raw material in the manufacturing of brick and Cement with minimal Impact[9].

Xiao-Hong Gnan have made an attempt the feasibility of reusing Water Treatment Plant (WTP) sludge to improve particulate pollutant removal from sewage[10].

Chung-Hsinwu analyzed the generation and reuse of WTP sludge asan absorbent for cations[10]. Mary Jean Yon reported the guidance for land application of Drinking water sludge[11].

Mirosla have analyzed the removal of organic matter and metallic contaminants using WTP sludge.

The opportunities for Water Treatment Sludge and its reuses has also been reported[12].

Husillos Rodriguez reported the strength and slump characteristics of cement mortar with the admixture of alum sludge[5].

Lucie N Asade have studied the effectiveness of utilizing the WTP sludge in pilot-scale Up flow Anaerobic Sludge Blanket (UASB) reactor, pilot scale Activated sludge system and in full-scale activated sludge Sequencing Batch Reactor (SBR).

It is observed that there is considerable amount of reduction in suspended solids and phosperus content[13].

A study on reuse of drinking water treatment plant sludge in agriculture was made by many researchers[2].

Maha Alqam have studied the utilization of cement incorporated with water treatment sludge.

It can also be used as an admixture for production of cement[14].

MATERIALS AND METHODS

Kuzhithuraiyar river is the only perennial river in Kanyakumari District and is the source for many water supply schemes.

Table 1: WTP at River Kuzhithuraiyar

S No	Name of WSS	Capacity of WTP MLD	Population Benefited
1.	Edaicode, Pazhugal combined WSS	4.42	77,575
2.	Kuzhithurai Municipality WSS	3.00	30,000
3.	79 Coastal CWSS	14.96	3,74,546
4.	Kuzhithuraiyar CWSS	17.090	3,06,753
5.	Kaliakkavilai CWSS	11.5 MLO	2,37,338
		50.970	10,26,212

Table – 1 shows the list of water treatment plant located nearby the river and the population benefited.

All the 5 WTPS of capacity 50.97 MLD are located within 2 km. distance along river Kuzhithuraiyar.

The raw water is tapped from the river and is treated for drinking water standards.

The average total suspended solids (TSS) of the water is in the range of 30 mg/L– 400 mg/L.

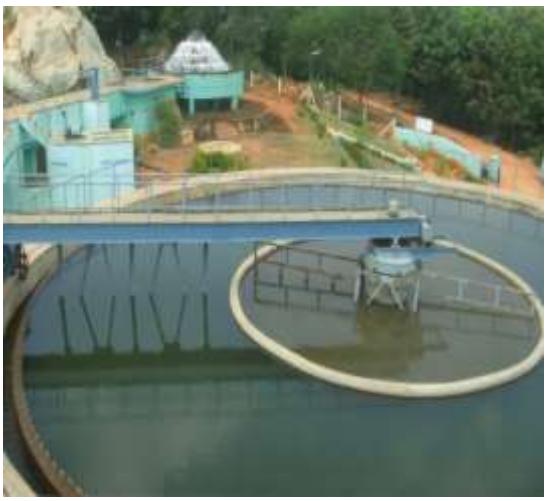

Figure 1: Water Treatment Plant

Figure 2: Sludge Drying Bed

There is considerable amount of algal growth in the raw water. Pre chlorination and subsequent lime dosing is also done in the WTP unit. The average Alum requirement is about 50 mg/L. The WTP sludge (solids 0.30%) is drawn from the clariflocculator and collected in the sludge drying bed. The dried sludge stored in opened yards and exposed to direct sunlight. These sludge is pulverized in order to obtain fine and uniformly distributed particle that can be used as a coagulant in the sewage treatment plant. The properties of the alum sludge are presented in Table – 2.

Due to continuous change in quality of the raw water and quantity of alum used for treatment the characteristics of the WTP sludge generated is also continuously fluctuating. Hence periodical analysis is carried out on the sludge.

Raw sewage has been collected from the community of Nagercoil Municipality and Kuzhithurai Municipality which is having the Parameter listed in Table 3.

Table 2: Alum sludge Parameters

S. No.	Parameter	Value
1.	p^H	6.80
2.	Aluminium (%)	13.88
3.	Total Nitrogen (%)	0.3
4.	Total Phosphorous (%)	0.12
5.	Total Potassium (%)	0.18
6.	Organic Carbon (%)	4.50
7.	Calcium (mg/kg)	125.00
8.	Megnesium (mg/kg)	85.00
9.	Sodium (mg/kg)	36.00
10.	Sulphate (mg/kg)	35.00
11.	Chloride (mg/kg)	150.00
12.	Copper (mg/kg)	33.00
13.	Zinc (mg/kg)	40.00
14.	Iron (mg/kg)	41.00
15.	Magnesium (mg/kg)	22.00
16.	Cadmium (mg/kg)	4.50
17.	Nickel (mg/kg)	5.30
18.	Lead (mg/kg)	8.50
19.	Silica (mg/kg)	70

Figure 3: Sludge from WTP

Table 3: Raw Sewage Characteristics

S. No.	Parameter	Raw Sewage Characteristics
1.	BOD_5 (mg/L)	270
2.	COD (mg/L)	600
3.	TSS (mg/L)	410
4.	Oil & Grease (mg/L)	80
5.	Faecal Coli form (MPN/100 ML)	60×10^5

The Municipal sewage and WTP sludge are employed in this study to determine the appropriate dosage of WTP sludge

Test Procedure and Condition

To obtain the optimum dosage of WTP sludge, jar tests were performed for a coagulation and flocculation process. The jar tests was performed with a rapid mixing at 120 rpm for 1 min which is followed by a slow mixing at 40 rpm for 10 min and 20 rpm for 10 min. Finally the mixtures were allowed for a 30 min settling. This test has been executed in a temperatures controlled room at 21°C. This tests were conducted mainly to study the influence of WTP sludge dosage, mixing speed, with various p^H conditions, on the improvement of TSS, COD and BOD removal from the raw sewage.

Hence the tests have been conducted with different amount of WTP sludge ranging for 1 mg/L to 20 mg/L with paddle mixing speed ranging from 100 rpm to 250 rpm with varying p^H condition for 6.50 to 8.00. After each test the supernatant of the mixture was sampled and measured for BOD, COD, TSS concentrations. Subsequently the settlement in the jar is also measured.

RESULTS AND DISCUSSION

The study shows from Table 2 and Table 3 that the alum sludge is with acidic in nature with pH value 6.80 and the aluminium concentration is of 13.88 which is highly objectionable for disposed into any water body or on Land. Further the standards of the treated sewage effluent should have the standard as per Table – 4.

Table 4: Disposal Standards of Sewage

S. No.	Parameter	Effluent Standard
1.	BOD_5	20 mg/L
2.	COD	250 mg/L
3.	TSS	30 mg/L
4.	Oil & Grease	10 mg/L
5.	Faecal Coli form	10^4 MPN / 100 ml

Table 5 shows that at p^H - 8 and Paddle speed with 250 rpm the removal efficiency of the BOD, COD, TSS, Oil and Grease and Coliform is maximum. When WTP sludge is introduced with the municipal sewage, the smaller particles which are in the suspended state ranging between 48 µm and 200 µm disappeared in the supernatant.

This obviously tells that the removal efficiency increased when dosing of WTP sludge increases.

When the WTP sludge dosing is at 20 mg/L there is a mixing settlement of organic matters which in turn reduce the BOD and COD concentration.

Therefore the enhancement of the TSS, BOD and COD removal by WTP sludge depends on the contaminants removed from the waste water phase as well as on those released from the WTP sludge.

When the dosage of WTP sludge is at 20 mg/L, the contaminants in the form of suspension removed by the WTP sludge for exceeded the contaminants that were released, thereby resulting in a considerable enhancement in the TSS, COD and BOD removal efficiencies.

At this dosage the BOD, COD, TSS and Coliform were found to be 23%, 22%. 20% and 63% respectively. Subsequently when the WTP sludge is used in the settling process, the volume of the sludge is also increased.

Hence repeatedly the experiment was conducted and a stable effluent quantity could be achieved at 20 mg/L WTP sludge dosage. It was also found that with the additional WTP sludge, the thickening and dewatering proportion of the combined sludge were improved in terms of final solid content.

It was also observed that the settling rate of floc were also increased by adding the WTP sludge with the raw sewage.

Further it is also inferred that, since the WTP sludge exerted a negative impact on the TSS and COD removal in the Primary sewage treatment, these negative contaminants will be helpful in controlling bulking of sludge in the secondary clarifier (Hsu and Pipes, 1973; Salotto).

Effect of Paddle Mixing Speed

Rapid mixing of WTP sludge make the particle size further smaller which will effectively react with the suspended particle of the raw sewage.

This will increase the higher removal of BOD and COD by adsorbing the particles and increasing the particulate pollutant removal.

Hence it is inferred that the paddle mixing speed takes and key role in removal of TSS and COD. During a rapid mixing, suspended solids and waste water molecules that are- attached to the WTP sludge through electro static bonds entrapped by aluminium precipitate may detach from the WTP sludge, thereby enabling the surface sites to be activated. Further the WTP sludge adsorbs micro particles to form large flocs with high settling rate.

The removal efficiency of BOD5, COD, TSS, Oil & Grease and Fecal Coliform in the Municipal Sewage while adding the WTP Sludge is shown in Table-5.

Table 5: Removal efficiency of WTP sludge on Sewage

S. No.	Parameter	Raw Sewage Character	Effluent Standard	Post Sewage Character @ p^H-8	Removal Efficiency
1.	BOD_5 (Mg/L)	270	20	209	23%
2.	COD (Mg/L)	600	250	467	22%
3.	TSS (Mg/L)	410	30	328	20%
4.	Oil & Grease (mg/l)	80	10	72	10%
5	Faecal Coliform MPN/100 ml	60×10^5	10^4	24×10^5	63%

CONCLUSION

Jar tests are conducted for evaluating the effect of water treatment plant sludge with the municipal sewage on the removal of BOD, COD, TSS and Coliform under various p^H conditions and mixing speed of the paddles. It was observed that a reasonable removal of BOD, COD, TSS and Coliform at p^H 8 and mixing speed of 250 rpm. The appropriate dosage of WTP sludge was noticed to be 20 mg/L. The thickening of the combined sludge improved and the settling rate of the flocs were increased with addition of WTP sludge. Coliform reduction was also observed reducing at p^H (8) and mixing speed of 250 rpm. Rapid mixing (250 rpm) optimized p^H (8) and appropriate dosing of WTP sludge (20 mg/L) will give maximum removal of TSS, COD, BOD, Oil and Grease and coliform which will subsequently reduce the power consumption in any municipal sewage plant.

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