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EFFECTS OF WTP SLUDGE DOSAGE AND PADDLE SPEED ON THE REMOVAL OF SUSPENDED PARTICULATE MATTER IN MUNICIPAL WASTE WATER

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ABSTRACT

Alum is used as a coagulant in a water treatment plant (WTP) to remove the turbidity and lime is used to balance the p^H value, a large volume of alum lime combined WTP sludge is generated. The sludge's characteristics depend on the water source and the quality and quantity of the chemicals used. 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. The scope of the study are (1)The quantity of BOD,COD, Total suspended solids in the treated water will be studied (2) The reactiveness of WTP sludge with the waste water will be studied by varying the operating paddle speed condition of the sludge. The WTP sludge will be applied with municipal sewage to a series of jar tests conducted under various operating paddle speed conditions at pH 7.95. 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, and operating paddle speed condition.

Key words: WTP Sludge, Operating Paddle Speed Conditions, Waste Water Treatment, Jar Test, BOD, COD, TSS.

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INTRODUCTION

Water exists on planet earth in the form of gaseous, liquid and solid and is circulated by planetary and solar forces. Human body contains about 75% of water in the mass of the body and mostly all the human organs have water content from 22% to 96%. Being an universal solvent, water picks up various impurities. The contaminants in the water are grouped into physical, chemical, biological, microbiological and radioactive characteristics. The main objective of water works management is to ensure that the water supplied to the public is clear, palatable, free from undesirable taste and odour, free from pathogenic organisms and free from minerals which could produce undesirable physiological effects. Establishing of minimum standards of quality for public water supply is of fundamental importance in achieving the objective. Water treatment is the scientific intervention by which the excessive contaminants can be removed and the treated water will meet the drinking water quality standards. Water purification process generates a large volume of sludge which are hazardous to public health. The characteristics of the sludge depend on the source of water and the quantity and quality of the chemicals used for processing. Since the sludge discharged from any water treatment plant is hazardous and the sludge discharged is having economic value, then it can be used in an effective manner.

Conventional Water Treatment Method

Conventional water treatment plant can remove odour, Algal growth, colour to some extent, iron, manganese, suspended particle and colloidal particles. A typical water treatment plant comprises of Pre chlorination, plain sedimentation, Aeration, Coagulation and Flocculation, Sedimentation and Clarification, Filtration and disinfection arrangements. The method employed for the treatment of water depends on the nature of raw water and the desired standards of water quality. The unit operation of the water treatment process constitute pre chlorination, aeration, flash mixing, coagulation, flocculation, clarification, filtration, disinfection, softening, de fluoridation, water conditioning. Depending upon the quality of raw water, the treatment process takes many different combinations to suite the required standards.

Commonly used coagulant chemicals are Aluminimum sulphate. Lime is effectively utilized for balancing the pH. Sedimentation is the process of settling of grown up settleable from micro flocs in the coagulation and flocculation process. This settled flocs at the bottom of the sedimentation tank or clarifier tank will be removed by hydrostatic pressure and will be taken to the sludge drying bed. This settled floc is known as sludge. This water works sludge from any WTP remains as an inescapable byproduct of the water treatment process. . The composition of sludge is mainly depends on characteristics of the raw water source, coagulant type, dosage of coagulant operating paddle condition, pH balancing condition and other plant operating conditions. This sludge generated from the WTPs are very much concern on their disposal practice. They have to be dispose safely without affecting the environmental and ecological factors.

CURRENT PRACTICE ON DISPOSAL OF WTP SLUDGE

In most of the existing water treatment plant, the WTP residues are now being disposed into water-bodies, located nearby or at the point of extraction of the raw water.

REUSE OF SLUDGE

Reuse of the WTP sludge will close the loop between efficient water treatment and sustainable sludge management.

SEWAGE

Sewage is a combination of the liquid waste from residences, business building and institutions (Domestic sewage), liquid waste from industrial establishment (Industrial sewage) and the runoff on streets, open yards etc after a rainfall (storm water).

Sewage contains 99.90% of water and 0.10% of solids which is the trouble shooter. Though the municipal sewage contains only 0.10 percent solids, and the rest being water, still the nuisance caused by the solids cannot be over looked, as they are highly putrefies and therefore need proper disposal.

Depending of the characteristics of the sewage, the methods of sewage treatment may be;

- Primary treatment or physical treatment
- Chemical treatment
- Biological treatment.

Solids separation may be done in a series of steps or only one or two steps so that its BOD gets reduced and the DO content should bring to normal level.

CHEMICAL TREATMENT

Chemical precipitation of sewage is as like as coagulation in water treatment process. Certain salts of heavy metals like iron or aluminium when added to sewage containing alkaline substances develop heavy precipitates which bring down with them colloidal suspensions.

There are also many practical constraints for disposing the WTP sludge through other methods such as land availability, mode of transportation and their cost, difficulty in handling sludge in the liquid form, long term effect of heavy metal concentration on soil and other environmental and ecological factors.

The primary objectives of this study are

- To explore the possibility of utilizing the water treatment plant sludge on waste water treatment.
- To optimize the WTP sludge usage by varying the operating paddle speed condition.

It is impossible to remove small particles which are less than 50 μm, in a conventional primary sedimentation tank. Thus to remove the suspended solids and chemical oxygen demand from the waste water in primary treatment, particle agglomeration through chemical coagulation is necessary. Usage of chemicals for the chemical coagulation needs high operation costs of the treatment plant and also produces large amount of chemical sludge.

While using the WTP sludge which is having unused chemicals in the activated condition for the removal of the suspended solids in the waste water, it gives more result oriented agglomeration of particulate matter.

JAR TEST

Jar test is a laboratory experiment to find out the optimum coagulant dose for the removal of particulate matter.

EXPERIMENT PROCEDURE

Jar tests were performed for a coagulation and flocculation process. Water treatment plant sludge was mixed with the waste water beaker in the rate of 1 mg/L, 2 mg/L, 3 mg/L, 10 mg/L, 15 mg/L and 20 mg/L and the pH of the WTP sludge was maintained at 6.80. Jar test was performed for the 6 Jars simultaneously with flash mixing 120 rpm paddle speed for 1 min,

subsequently 40 rpm for 10 min and 20 rpm for 10 min. Finally the compositions were allowed to settle for 30 min.

The settling rate of the residues was observed. The supernatant from the beakers have been tested for their quality and parameters.

Table 1 Sewage Characteristics and Disposal Standards

Sl. No.	Parameter	Raw Sewage Characteristics	Effluent Disposal Standard
1.	BOD_5 mg/L	270	20
2.	COD mg/L	600	250
3.	TSS mg/L	410	30
4.	Oil & Grease mg/L	80	10
5.	Fecal coliform MPN/100mL	60×10^5	10^4

The raw sewage water was collected from the area of Nagercoil Municipal Corporation. WTP sludge was collected from the water treatment plant at Kuzhithurai. The raw water is tapped from river Kuzhithuraiyar where the nominal turbidity is in the range of 40 mg/L to 400 mg/L. The WTP sludge has been analyzed for its character and is listed in Table 2.

Table 2 Characterization of WTP Sludge for Prime Contaminants

Sl. No.	Parameter	WTP Sludge Characteristics	Disposal Standards for Drinking Water
1.	Ph	6.80	6.5-7.50
2.	Aluminium	13.38	0.2
3.	Silica mg/kg	70	-

EFFECT OF WTP SLUDGE DOSAGE ON THE REMOVAL OF BOD, COD AND TSS

Since WTP sludge is a combination of Alum sludge and calcium sludge it will as an active chemical coagulant which will lead the process of coagulation and flocculation of micro suspended particle in the waste water. During the jar test conducted in the laboratory, as the dosage of the WTP sludge is increased there is a reasonable settlement of suspended solid got settled and the BOD, COD and TSS consents gets considerable reduced. Jar test results shows that up to 20mg/L of dosage of WTP sludge, the waste water parameters BOD, COD & TSS a getting reduced. Beyond that even the dosage is increased, there is not much reduction in the removal of the waste water parameters. It is also observed that at 20 mg/L dosing of WTP sludge there is a considerable amount of removal of BOD around 23%; COD around 22% and TSS around 20%. Simply adding the WTP sludge with the waste water does not show any significant effect on the removal of micro organisms. But while the operating paddle speed condition is increased for the system, at 20 mg/L loading of sludge there is a considerable amount of reduction in fecal coli form.

EFFECT OF OPERATING PADDLE SPEED CONDITION ON THE REMOVAL OF BOD, COD AND TSS AND FECAL COLIFORM

The pH of the WTP sludge is analyzed as 6.80, which is slightly acidic. Normally when pre chlorination is applied for the treatment of algal growth the excess residual chlorine reduce the pH of the raw water. To make the Alum for effective function, lime solution will be added with the raw water so as to bring back the pH normal. Hence along with alum sludge, lime sludge will be also in the settling tank. During the jar test, pH of the system was maintained in the beginning. It was noticed that the settlement of the suspended solids from waste water was comparatively less when pH of the system was increased by adding lime solution, then it was noticed there was considerable settlement of the micro particle get started. In addition with the

WTP sludge, the settlement improves and the supernatant solutions shows less BOD, COD and TSS. It was noticed that at pH 7.95, there was considerable amount of reduction of Fecal coliform takes place. At pH 8, around 60% of the fecal coliforms get reduced.

For any waste water treatment plant, since the biological process only conform the disposal standard of the supernatant, it is a serious problem of maintaining and growing the microorganisms. Hence the pH 7.95 is an optimum one for the removal of BOD, COD and TSS in the waste water treatment.

pH plays a vital role the removal of waste water parameters, such as BOD, COD and TSS. It was observed, that when the pH of the system is at 7.95, the removal efficiency of the parameters is maximum.

Influence of Operating Paddle Speed Condition at 250 rpm

This operating paddle speed condition is the optimum condition for the maximum removal of pollutant. At the sludge loading rate of 20mg/L and pH 7.95are the removal efficiencies of the pollutant parameter BOD is 22% (Figure 1), COD is 23% (Figure 2) and TSS is 22% (Figure 3). Beyond the operating paddle speed condition there is no considerable amount of removal of the suspended particles.

The supernatant solution of the waste water after conducting the jar test experiment at pH 7.95 has been presented here. At a flocculator paddle speed of 120 rpm, the BOD removal from the waste water starts from 3% at 1mg/L sludge dosage and it increases while increasing the sludge dosage. At 20 mg/L the maximum removal of BOD was observed at 8%. Beyond that even the dosage rate is increased there is no much variation in the BOD removal efficiency. At a paddle speed of 150 rpm the percentage of BOD removal efficiency is 6% at 1mg/L sludge dosage and reaches 11% at 20mg/L dosage. At a paddle speed of 175 rpm, the percentage removal is 6.6% at 1mg/L sludge dosage which gradually increases to 11.1% at 20mg/L dosage. When the paddle speed is raised to 200 rpm the BOD removal efficiency starts at 7.4% at 1mg/L dosage and it reaches 17% at 20 mg/L dosage .When the paddle speed is at 250 rpm the removal efficiency of BOD is 8% at a sludge dosage of 1mg/L. When the dosage increases to 20mg/L the BOD removal is 22%. Beyond that even the dosage is increased there is no considerable increase in the BOD removal. The result implies that the percentage of removal of BOD depends upon the flocculator paddle speed as well as the sludge dosage as shown in Figure 1.

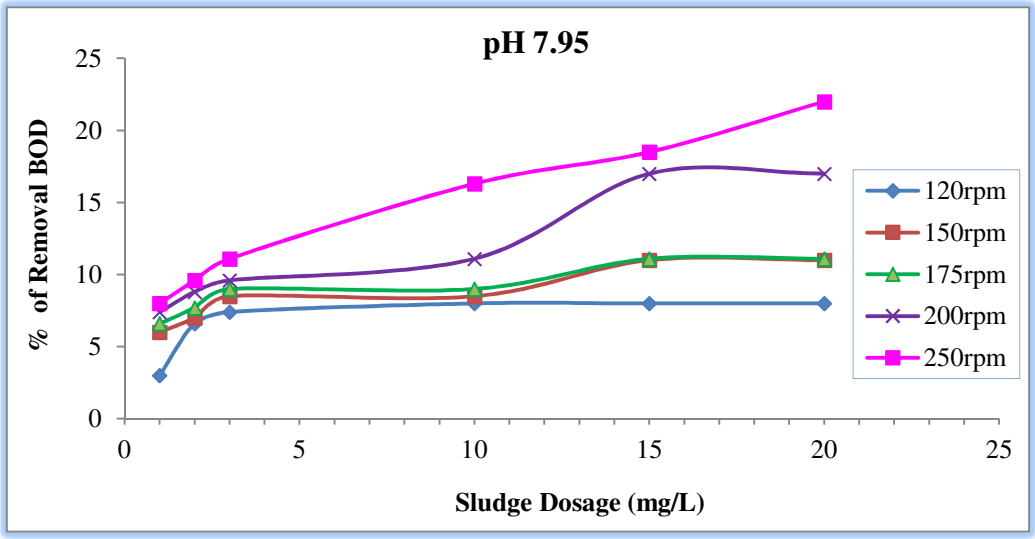

Figure 1 Influence of Operating Paddle Speed Condition at 250 rpm

Influence of pH 7.95 on Removal of BOD

The results of the analysis of the supernatant solution of the treated waste water for COD at a pH of 7.95 has been presented in Figure 2. At a paddle speed of 120 rpm the percentage of COD removal starts with 5% at a sludge loading rate of 1mg/L. The COD removal increases when the sludge dosage increases and it is 14% at a sludge loading rate of 20mg/L .At a paddle speed of 150 rpm the removal efficiency of COD starts with 5% at 1mg/L dosage and attain a maximum of 17.5% when the sludge dosage is at 20mg/L. While the operating paddle speed is increased to 175 rpm, the removal efficiency of COD is 5% at 1mg/L sludge dosage. At a sludge dosage of 20mg/L, the maximum removal of COD is attained and is 18%. At a paddle speed of 200 rpm the COD removal efficiency is 5% at 1mg/L dosage and is 18.6% at 20mg/L dosage. Hen paddle operating speed is increased to 250 rpm; COD removal efficiency is 5.6% at 1mg/L dosage and 23% at 20mg/L dosage. Beyond that even the dosage of the sludge is increased there is no considerable improvement in the removal efficiency of COD.

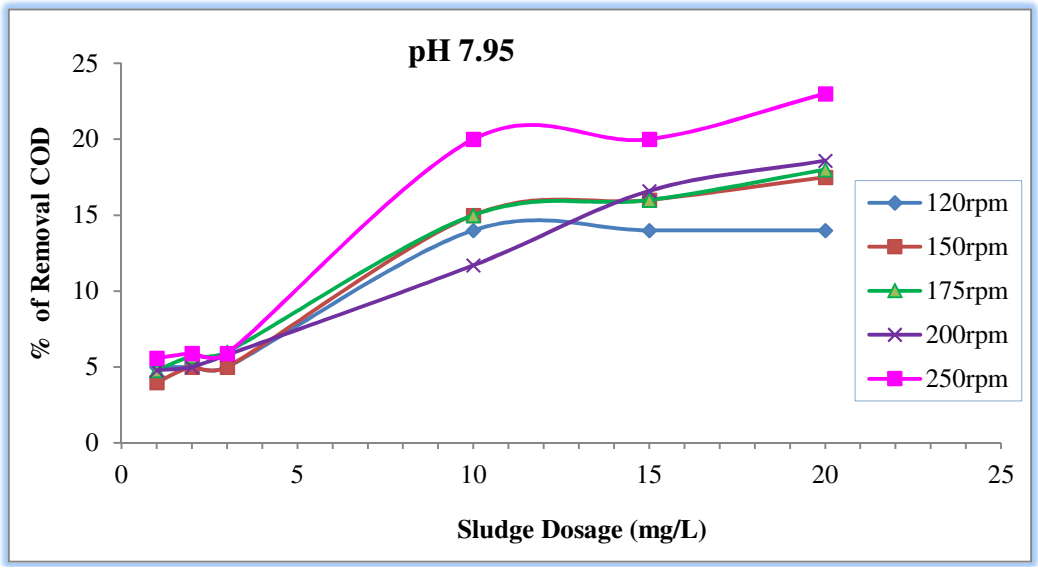

Figure 2 Influence of pH 7.95 on Removal of BOD

Influence of pH 7.95 on Removal of COD

The results of the analysis of the supernatant solution of the treated waste water for TSS at the pH of 7.95 has been presented in Figure 3. AT the paddle speed of 120 rpm with sludge dosage of 1mg/L the percentage of removal of TSS is 2%. This is increased when the sludge dosage is increased. At 20mg/L dosage, there was a maximum 6% removal of TSS. At the flocculate speed of 150 rpm with sludge dosage of 1mg/L, the TSS removal efficiency is 6 %. While the dosage increases the percentage of removal of TSS is also increased and is 7.0 % at 20mg/L. Beyond that there is considerable improvement even the dosage is increased. At 175 rpm the removal of TSS is 6.8% with a dosage of 1mg/L and is 12% with a dosage of 20mg/L. At 200 rpm paddle speed with 1mg/L sludge dosage the percentage of removal of TSS is 7.3%. It increases if the dosage of sludge is increased. At 20mg/L Sludge dosage the maximum removal efficiency was 19.5% beyond that even the dosage is increased there is no considerable in the removal efficiency of TSS. At 250 rpm paddle speed with 1mg/L sludge dosage the percentage of removal of TSS is 7.8%. It increases if the dosage of sludge is increased. At 20mg/L Sludge dosage the maximum removal efficiency was 22% beyond that even the dosage is increased there is no considerable in the removal efficiency of TSS. The result implies that the removal efficiency of TSS depends on the paddle speed which is maximum at 250 rpm and the maximum removal is noticed at 22%.

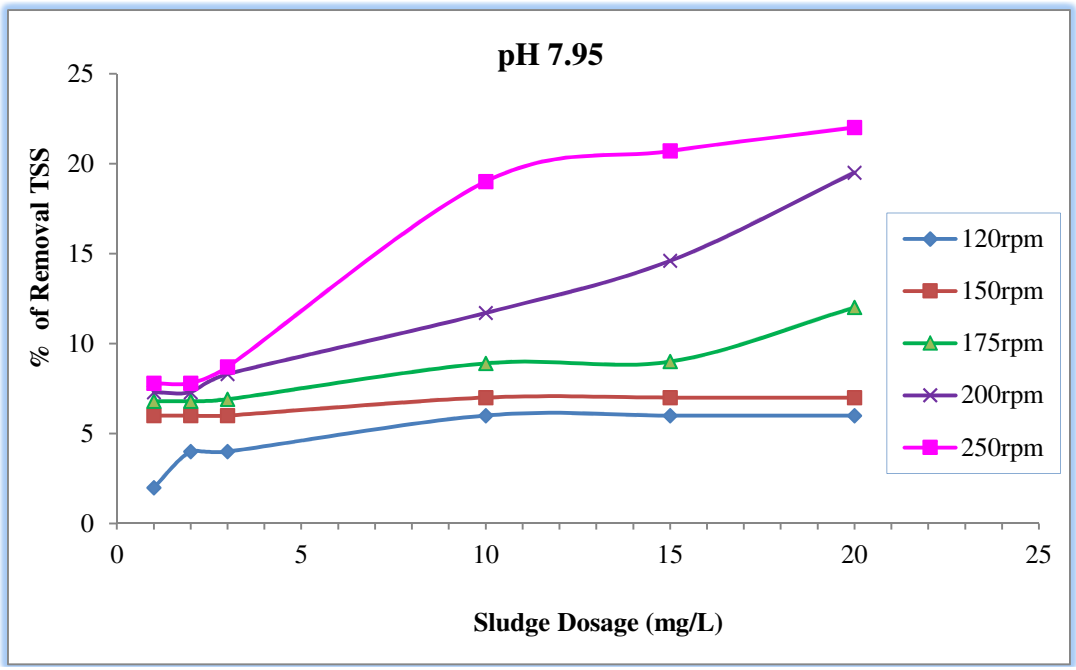

Figure 3 Influence of pH 7.95 on Removal of COD

Influence of pH 7.95 on Removal of TSS

Table 3 Characterization of STP Sludge

Sl. No.	Parameter	WTP Sludge Characteristics	STP Sludge Characteristic after Application of WTP Sludge
1.	Ph	6.80	7.4
2.	Aluminium mg/L	13.88	6.43
3.	Silica mg/kg	70	90

CONCLUSION

The characteristics of the STP sludge after the application of WTP sludge is studied. The pH of the STP sludge is 7.4. This may be due to the application of WTP sludge. Particularly the Aluminium content of 13.88 mg/L is considerably reduced to 6.43mg/L is around 53% of the Aluminium has been used in the waste water treatment process. The silica content has increased in the STP sludge which will not produce any adverse effect in the environment. Even though the residual aluminium in STP sludge is around 6.43mg/L, the harm is considerably reduced, since their content is combinely used as manure from the STP.

Further, the WTP sludge with economic value which could be recovered by reusing the sludge. In this paper, it has been presented the possibility of using the WTP sludge in the treatment of municipal waste water. The WTP sludge was added with the municipal waste water in certain predestined proportions and jar test was conducted. The dosage of the WTP sludge and operating paddle speed conditions were kept as variables and jar test was conducted. The supernatant of the treated effluent were tested for their characters and the percentage of removal of the prime parameters has been studied. The removal efficiency of the WTP sludge on the waste water has also been studied at pH 7.95.

From the present study, it is observed that water treatment plant sludge could be utilized for the treatment of municipal waste water in the primary treatment stage, so as to recover the economical value of the WTP sludge. In addition to that there was a considerable amount of suspended particulate pollutant parameter could be able to remove and hence the subsequent

treatment would be comparatively easy and cost effective for waste water treatment. The aluminium concentration in the WTP sludge could be considerably reduced up to 53% by reusing the sludge.

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