EFFICIENCY OF THE COAGULATION AND FLOCCULATION METHOD FOR THE REMOVAL OF TURBIDITY AND ALGAE FROM THE SURFACE WATER OF DRY ARU.

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There is frequent water scarcity in Sri Lanka as a result of spatial and temporal variations in rainfall and changing weather patterns. Huge seasonal fluctuations of turbidity and algal density in Dry Aru affect the performance of the Water Treatment Plant in Kilinochchi (KWTP). As per the operation manual, raw water turbidity must be less than 80NTU before it enters Water Treatment Plant (WTP). However, the laboratory records indicate that the turbidity increases to 320NTU-350NTU during the rainy season and algal density increases to 50 x 10^4-75 x 10^4cells/ml during dry seasons stopping the plant's efficient operations. This study aimed to evaluate the turbidity and algal removal efficiency of the coagulation-flocculation process and to ensure the continuous operation of WTP during adverse water quality conditions. During the test period, raw water turbidity vary between 10.4 to 325 NTU and the average algal density was 57.63 x 10^4 cells/ml. Aluminium Sulphate (Alum) and Poly Aluminium Chloride (PACL) were tested as coagulant chemicals. The optimum performance of both coagulants was observed at the coagulation speed of 300rpm and 1st stage flocculation speed of 30rpm for 10 minutes and 2nd stage flocculation speed of 10rpm for 10 minutes and the settling time of 30 minutes. Alum's effective turbidity removal range was 60-140 ppm and PACL was 20-40ppm. Prechlorination didn't show significant improvement in the turbidity removal efficiency of both coagulants. PACL dose of 35ppm reduces turbidity from 325NTU to 1.92NTU with and without Prechlorination. The most abundant algal species in Dry Aru were Synechococcus, Chroococcus, Gloeocapsa, Microcystis, Oscillatoria, Anacystis, and Anabaena. The algal removal efficiency of PACL and Alum 87.86% and 85.44%, respectively. The algal removal efficiency of PACL increased from 87.86% to 90.74% and Alum increased from 85.44% to 88.93% when 1ppm prechlorination was used. It can be concluded that PACL is working more effectively than Alum for Dry Aru in terms of turbidity and algal removal. The turbidity removal efficiency of 98-99% and algal removal efficiency of 87.86% to 90.74% can be obtained by coagulation-flocculation process by using PACL as a coagulant and thereby raw water turbidity can be brought to the level indicated in the operational manual.

Keywords: Turbidity, Algae, Coagulant chemical, Coagulation Flocculation

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Introduction

It is a real challenge to monitor and control the water quality of Dry Aru which is an intake for the existing and proposed water treatment plant in Kilinochchi district. Huge seasonal fluctuation of some of the water quality parameters of Dry Aru affects the performance of the existing water treatment plant at Kilinochchi (KWTP) which has a capacity of 3,800 m3/ day. The treatment process of KWTP is pumping water from the intake to Roughing filter (RF) to the aerator to the Slow sand filter (SSF) and finally to clear water ground sump. As per the KWTP operation manual, the raw water turbidity level must be less than 80 NTU before it enters the RF for proper operation (NJS Consultants Co., 2019) and the effluent turbidity level must be less than 30 NTU before entering into the SSF to prevent clogging of the filter media of SSF (NWSDB, 1989). However, the turbidity of raw water increases to 325-350 NTU during the rainy season, stopping the plant's efficient operations. The intake structure is located close to the reservoir outlet sluice gate of Dry Aru which is also one of the main reasons for the sudden increase of turbidity when opening the gates. Algae blooms is a seasonal problem in Dry Aru during the August to September period which is the driest period in Kilinochchi. Algal density increases to 50 x 10^4-75 x 10^4 cells/ml during Dry seasons due to strong sunlight and this causes odour and colour problems in Dry Aru as well as in the treatment plant components. Algae growth on filter media of RF and SSF was one of the major issues for the operation and maintenance team of NWSDB. The water supply to the public from KWTP was stopped during the rainy and dry seasons due to high turbidity and algal density of Dry Aru intake.

Therefore, the existing plant should be modified to treat the water during high turbidity and high algal period. In this research, the turbidity and algal removal efficiency of the coagulation-flocculation process for Dry Aru is studied.

Material & Methods

Study Area:

The Kilinochchi water treatment plant (KWTP) was designed to cover 40,000 people in fourteen (14) numbers of Grama Niladhari Divisions of Karachchi and Kandawali DS Divisions in Kilinochchi District. The KWTP had been designed for a treatment capacity of 3800 m3/day. The components of the KWTP are intake, intake sump, low lift pump house, raw water transmission line from the intake, roughing filter (02 units), aerator, slow sand filters (03 units), clear water sump, and a high lift pump house. The Dry Aru tank is the water source for the KWTP. Raw water for this study is collected from Dry Aru and sampling was done in weekly intervals.

A jar test apparatus was used with the aim of selecting the best coagulant chemicals and the effect of pre-chlorination, coagulation-flocculation speed, and settling time on turbidity removal and algal removal efficiency in the coagulation-flocculation process. Coagulants of Alum and PACL were tested from 10-120ppm in order to select the best coagulant chemical and correct dosage.

Turbidity was measured by a 2100Q turbidity meter. pH was measured by a pH meter. Colour and residual Aluminium were measured by HACH DR 890 meter at the site laboratory of NWSDB, Kilinochchi. Algal counting was done at the Department of Botany, University of Jaffna. The last three years of existing data were collected from the National Water Supply and Drainage Board, Jaffna to study the variation of turbidity and algae.

Results and discussion

Analysis of secondary water quality data of Dry Aru

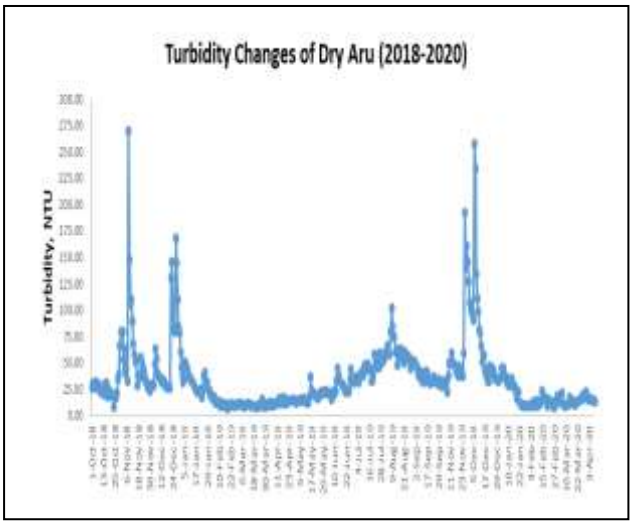

Figure 01: Turbidity variation

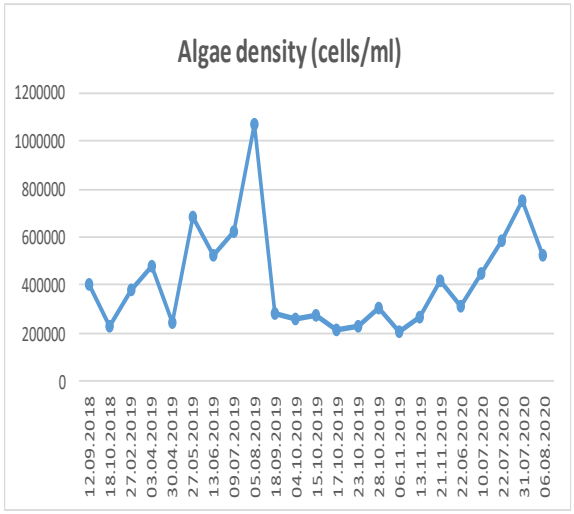

Figure 02: Algal density variation

Previous data on Dry Aru shows that there is a clear seasonal fluctuation of turbidity and Algal population density. During the rainy seasons, turbidity of the intake area increases tremendously and in the dry season, there is a problem of Algae blooming. Figure 01 shows that turbidity of the Dry Aru increases from November to January which is the rainy season in the study area and Figure 02 shows that Algal density increases from August to September which is the driest period in Kilinochchi district.

Previous records show that the existing plant does not support during these extreme turbidity and algal periods and plant operation was shut down during these periods. NWSDB uses alternative sources to meet consumer demand.

Coagulation-flocculation study

Selection of coagulant chemicals

Table 1: Effective concentration of alum and PACL

Initial Raw water Turbidity(NTU)	Effective concentration of Alum(mg/l)	Effective concentration PACL (mg/l)
10.4	70	20
47.5	60	35

174	100	30
325	140	40

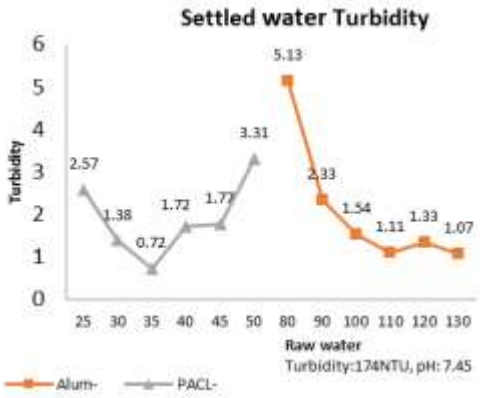

Figure 03: Settled water turbidity

Coagulant chemicals of Alum and Poly Aluminum Chloride (PACL) were tested to select the best coagulant chemical for Dry Aru by using Jar test apparatus. Effective dosage level means coagulant dosage required to reduce the initial turbidity to less than 2 NTU (SLS 614) in settled water of Jar testing procedure. It was found that Alum's effective turbidity removal range was 60-140ppm and PACL is 20-40ppm. As both coagulant chemicals are basically aluminium-based complexes, residual aluminium level in settled water plays an important role, and it affects the microbial activity of SSF. Residual aluminium was 0.202-0.411ppm in settled water when alum was used as a coagulant and 0.243-0.254 ppm remains for PACL. By considering the turbidity removal efficiency and residual aluminium after treatment, the PACL was selected and it was used for further studies.

Study of prechlorination in turbidity removal efficiency coagulation-flocculation technique.

Prechlorination of 0.5ppm and 1.5ppm was used before adding PACL in order to identify the effect of prechlorination on coagulation-flocculation process in terms of turbidity removal of raw water. PACL dose of 35ppm reduces the turbidity of the raw water from 325NTU to 1.92NTU with and without prechlorination.

Selection of floculation speed and time.

A coagulation speed of 300rpm was followed in order to ensure the effective mixing of the coagulant with raw water. Various flocculation speed was tested for 10 minutes interval and the effect of flocculation speed on turbidity removal was compared by analysing the settled water turbidity. The 30-50 rpm was used for 1st 10 minutes of flocculation and 10-15 rpm was used for 2nd 10 minutes of flocculation. Flocculation speed should be reduced with time in order to enhance the particle growth and form large flocs which can be easily settled. Based on the settled water turbidity, 30rpm was selected as 1st 10 minutes flocculation speed and 10rpm was selected as 2nd 10 minutes flocculation speed.

Selection of settling time.

Settling times of 30 minutes and 45 minutes were tested in order to identify the effect of settling time on turbidity removal efficiency of the coagulation-flocculation process. It was found that there was no significant difference in settled water turbidity with settling time and most of the flocs settled within 30 minutes time and it was selected as a settling time.

Algal density reduction by the coagulation-flocculation process.

Table 02: Average Algal removal efficiency of Alum and PACL

Categories of Algae	**Average algal removal % by Alum**	**Average algal removal % by PACL**
Unicellular	81.21%	86.94%
Colonial	89.06%	85.94%
Filamentous	71.43%	78.57%
Diatoms	100%	100%
Total algae count	85.44%	87.86%

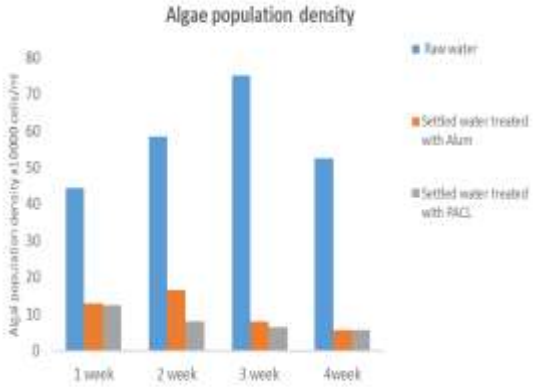

Figure 04: Algae density reduction by Alum and PACL

Above testing was carried out during July- August which is the dry period in Killinochchi and algal population growth is very high during this period. An average of 57.63 x 10^4 cells/ml algal population was identified in the raw water of Dry Aru. In that 39.25 x 10^4 cells/ml of unicellular, 8 x 10^4 cells/ml of colonial form algae, 8.75x 10^4 cells/ml of filamentous form algae, 1.625x 10^4 cells/ml of diatoms were identified. Mostly identified species in raw water are *Synechococcus, Chroococcus, Gloeocapsa, Microcystis, Oscillatoria, Anacystis,* and *Anabaena.*

20-40ppm of PACL and 60-140ppm of Alum were used for the coagulation-flocculation process by considering the turbidity removal efficiency and settled water was analyzed for algal population density. When considering the total algal population density, PACL works more effectively than Alum for total algal removal. An average of 87.86% (71.91-91.33%) of the total algal population is removed by the PACL. Almost all the diatoms are removed by both coagulant chemicals.

Study of prechlorination in Algal removal efficiency of coagulation-flocculation technique.

1ppm of prechlorination was used to identify the effect of prechlorination on algal removal efficiency. The efficiency of PACL increased from 87.86% to 90.74% and alum increased from 85.44% to 88.93%. Only around 3% improvement is identified by adding prechlorination and the negative effect of the prechlorination should be studied in terms of algal toxin formation and other organic by-product (Trihalomethane) formation before doing prechlorination.

Conclusion and Recommendation

It can be concluded that PACL works more effectively than Alum for Dry Aru in terms of turbidity and algal removal. Turbidity removal efficiency of 98-99% and algal removal efficiency of 87.86% can be obtained by coagulation-flocculation process by using PACL as coagulant at optimum coagulation-flocculation speed and time and thereby raw water conditions can be brought to the level indicated in the operational manual.

It is recommended to study the Negative effect of the prechlorination in terms of algal toxin formation and other organic byproducts (Trihalomethane) formation before doing prechlorination. The effect of residual aluminium on the biological effect of the slow sand should be studied by designing the pilot plant.

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