A Study On The Perfomance Of Sedimentation Tank At The Sungai Kampar Water Treatmeny Plant

Ir Dr Mohd Nordin Adlan[1]
Assoc. Prof. Dr Hamidi Abd Aziz[1]
Ir Mohd Yusuf Mohd Isa[2]
Abd Razak Zainal Abidin[2]
Rahmat Hasan[3]
[1] School of Civil Engineering, Universiti Sains Malaysia, Perak Branch Campus, 31750 Tronoh.
[2] Lembaga Air Perak, Ipoh.
[3] Former student, School of Civil Engineering, Universiti Sains Malaysia, 31750 Tronoh.

ABSTRACT

This paper discusses the performance of solid-liquid separation process at the Sg Kampar Water Treatment Works. Samplings of raw w and sedimentation treated water were made and the results were analysed. It was found that additional jar test must be conducted when t is a sudden change in the raw water quality. Furthermore the retention time in the tank need to be studied for the optimising of the solid-li separation process.

INTRODUCTION

Sedimentation involves the removal of solids particles from a suspension by settling under gravity prior to filtration (Barnes et al., 1981). In order to achieve or to permit suspended solids to settle out of the water by gravity, the velocity of flow must be reduced and under laminar condition (Twort *et al.*, 1985). There are many different designs of sedimentation tanks and according to Twort et al. (1985) the approach is still empirical. However in most cases there must be an equal distribution of water at the inlet with a reduced velocity so that the flocs are not breaking up. The principles governing the design of horizontal sedimentation basins are well documented in standard texts (American Water Works Association, 1990; Schulz and Okun, 1984; Twort *et al.*, 1985; Smethurst, 1988).

The design of sedimentation basin can be classified into two namely horizontal flow and up-flow units. According to Schulz and Okun (1984) horizontal flow tank has performed considerably well for decades. Removal of turbidity for the raw water can be up to 95% following an effective coagulation and flocculation.

The rate of coagulation of particles in a liquid depends on the number of collisions betweeen particles due to their relative motion (Coulson *et al.*, 1991). When that motion is mainly due to Brownian movement, it is termed as perikinetic coagulation. If the relative motion is caused by velocity gradients coagulation, it is termed as orthokinetic. In 1917, von Smoluchowski obtained the collision frequency I_s of particles using the following equation (Coulson et al., 1991):

$$I_s = 4\pi D_{12} n_2 (a_1 + a_2) \tag{1}$$

where, a_1 is the central reference particle, a_2 is the radius of particles, n_2 is the number of concentration, $D_{12}= D_1+D_2$; D_1 and D_2 are absolute diffusion coefficients given by Stokes-Einstein equation:

$$D_1 = KT/(6\pi\mu a_1) \tag{2}$$

$$D_2 = KT/(6\pi\mu a_2) \tag{3}$$

where, K is the Boltzmann's constant ($=1.38\times10^{-23}$J/°K and T is the temperature in °K.

Smoluchowski model leads to the result that the total number of collision per unit volume in unit time is given by:

$$N = \frac{2}{3} n^2 G d^3$$

where n is the number of particles unit volume, G is the velocity grad and d is the particle diameter.

With regard to flocculation, Camp Stein (1943) demonstrated that the sp of flocculation is directly proportion the velocity gradient at a point. It be determined by the number of cont between floc particles, in unit time assuming the flocs are in spher shape, Camp and Stein (1943) indic that the total number of contacts per time is given by the following equa

$$N = \frac{1}{6} N_1 N_2 (d_1 + d_2)^3$$

where N_1 is the number of pa diameter d_1 and N_2 is the nu particle of diameter d_2.

Wells and LaLiberte (1998) indic there are uncertainties hydrodynamics of clarifi designers often used safety account for this non-id behaviour. The latter may d following factors:

- Inlet and outlet geometry
- Inflow jet turbulence
- Dead zone in the tank
- Resuspension of settled solids and
- Density currrents caused by suspended solids and temperature differentials within the tank.

It can be summarised that the effectiveness of solid-liquid separation using sedimentation is depending on the chemical and physical processes. Chemical reaction involves with the choice of appropriate coagulant and intensity of collision whereas physical process involves with the agglomeration of the particles in a favourable environment.

This paper discusses the effectiveness of solid liquid separation process using horizontal flow settling basin at the Sungai Kampar Water Treatment Works. Data of raw water and sedimentation treated water were collected and analysed on its turbidity for approximately two weeks. The objective of this paper is to evaluate the effectiveness of sedimentation process at the Sg. Kampar WTW.

EQUIPMENT AND METHODS

Sungai Kampar Water Treatment Works (WTW) is situated on the bank of Sg Kampar near Kuala Dipang, Perak. The treatment plant was commissioned over 30 years ago and has a capacity of approximately 10 MLD (million litres per day). Treated water is supplied to areas such as Malim Nawar, Kampong Keram, Kuala Dipang and a number of rural areas in Gopeng. Raw water is pumped to the treatment works from an intake, which is at a distance of approximately 130 metres. The intake works is located on the bank of Sg. Kampar. The tributary of Sungai Dipang and Sungai Kampar is about 1 km upstream of the intake. The catchment area is made up of ex-mining land, agricultural areas and forest reserved beside a number of aboriginal settlements and Malay reservations. A small town called Sg. Siput South is located within the catchment area.

Treatment process involves screening, coagulation, flocculation, sedimentation, filtration, pH conditioning, fluoridation and disinfection. Raw water quality in terms of turbidity is always changing depending on weather condition and upstream activities. During rainy period the turbidity may rise well above 300 NTU. The increase in turbidity is mainly due to rural erosion. However before the fallen of tin price, the deteriorating in water quality is mainly due to mining activities.

Samples for turbidity measurements were taken at the inlet of the treatment works and at the outlet weir of the sedimentation tank. At each point three samples were tested and the average readings were used as a representative turbidity. The retention time in the sedimentation tank was calculated based on the volume of the tank and flow rate at the time of the investigation. The time of water body reached at the inlet was recorded in order to know the time to collect the sample at the outlet of the tank. The latter was carried out based on the retention time of the water body in the coagulation, flocculation and sedimentation tanks. All turbidity measurements were made using Hach turbidimeter, which was standardised with latex suspension supplied by the manufacturer.

RESULTS AND DISCUSSIONS

Fig. 1 shows the results the turbidity for raw water and sedimentation treated water. It can be seen that the raw water turbidity had increased to nearly 300 NTU during the study period. The latter was due to heavy rainfall encountered for that particular event. The removal of turbidity (Fig.1, Series 2) as indicates by the plotted graph for this event can be considered satisfactory. However for raw water of lower turbidity readings at less than 50 NTU (at the sampling sequence number 7 in Fig. 1) the removal is not satisfactory. Instead of decreased in turbidity, the result indicated that there was in increased in turbidity reading for the sedimentation treated water. This result was based on a total retention time of 7 hours and the dosage of alum was made based on the jar test. Weather record indicated that there was a downfall in the evening. The latter caused a sudden change in raw water quality and may affect the sedimentation treated water due to the occurrence short-circuiting in the flow regime or lack of alertness from the operator. In order to prevent the occurrence of the same event (at the sequence number 7 in Fig. 1), it is advantageous for the novice or experience engineers to develop a characteristic curve to identify the relationship between an optimum chemical dosage for different turbidities or suspended solids concentrations.

The details of retention time in the flocculation and sedimentation basins are shown in Fig. 2. The retention time in the coagulation and flocculation tanks during the study period was calculated between 1 hour 15 minutes to 1 hour 45 minutes. This indicates that the minimum retention time in the sedimentation tank is 5 hours 45 minutes based on a total retention time of 7 hours. From the graph, it can be seen that the theoretical retention times in the tanks varied between 7 to 10 hours during the study period. The retention time was calculated based on the volume of the tank divided by the flow rate observed during the investigation. The retention time at the plant is considered not in agreement with those of horizontal basins recommended by Schulz and Okun (1984), which is at a maximum of 4 hours for small installation with precarious operation. For sedimentation tanks with good operational procedures, the retention time can be reduced up to 2½ hours. Detailed study on the geometry of the sedimentation tank indicated that there is a bottleneck at the inlet of the tank, which may contribute to turbulent condition in the flow regime. As built plan indicates that the water from the distributing channel (after undergone flocculation process) has to pass through a comparatively small opening before entering the sedimentation tank. This opening may induce the flocs to break down or become unstable. In order to stabilise the flocs, a compartment was constructed in the inlet zone. Then the water was directed to a submerged wall before a proper sedimentation process took place. The design of the solid-liquid separation process may be based on other treatment works, which had been constructed overseas or some other places in the country. If an optimisation of solid-liquid separation process is required, there is a need for further study to be carried out at this treatment plant. Mathematical and physical modelling in the laboratory may be advantageous to understand the ambiguity relating to the flow characteristics within the tank.

CONCLUSION

It can be concluded that the possibility of short-circuiting in the flow regime of the sedimentation process during a sudden change in turbidity need to be investigated so that the turbidity of sedimentation treated water is always less that the raw water. The operator should also be advised to conduct a jar test, monitor and compare the quality of raw and sedimentation treated water during a sudden change in raw water quality. Further study should be carried out to optimise the retention time in the sedimentation tank.

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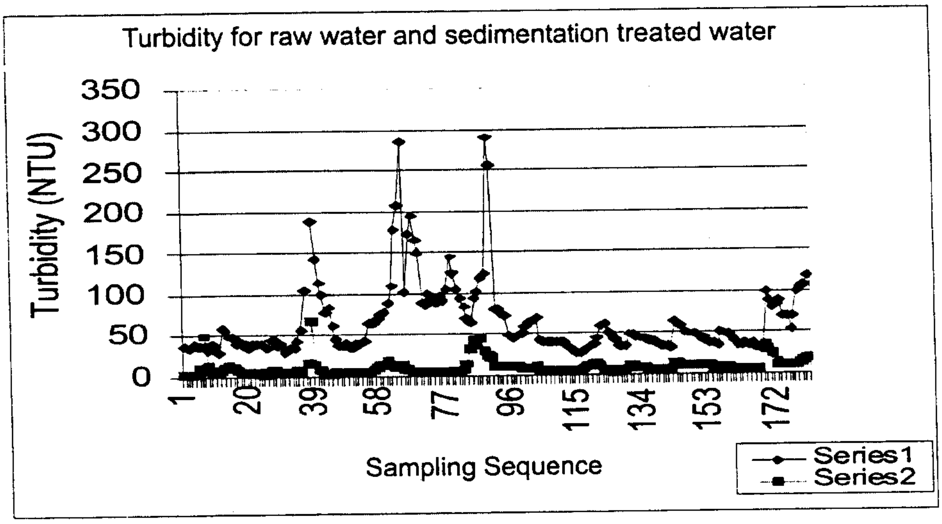

Fig.1 - **Turbidity readings for raw and sedimentation treated water.**
Note: Series 1 = turbidity for raw water, Series 2 = turbidity for sedimentation treated water and x-axis represents the sequence of sampling observation during the study period (an average of 8 observations per day).

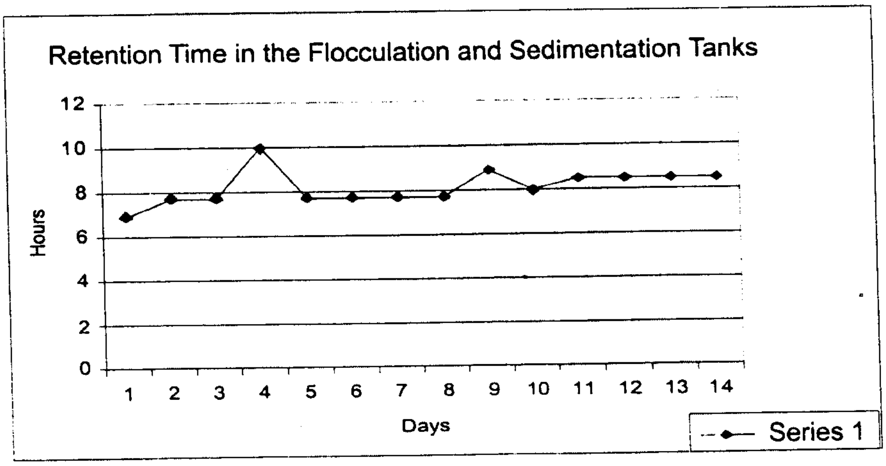

Fig. 2 - **Retention time in the flocculation and sedimentation tank during the study period.**