# FISH WASTEWATER TREATMENT WITH "PACP" FILTER AND REUSE OF THE TREATED WATER

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## ABSTRACT

Powdered activated carbon pellet (PACP) filter was found very effective for the removal of chemical oxygen demand (COD) and nutrient from the fish wastewater. It was found in the study that fish waste water generated from rearing tilapia fish in a glass aquarium for 48 hours had high organic and nutrient content. This high organic and nutrient containing wastewater while passed through the 30 cm PACP filter could remove 90% COD, 93% phosphate and 85% ammonia nitrogen after 10 L of fish wastewater loading. The optimum flow rate for the PACP filter was 100 ml/min. In a comparative study it was found that PACP filter had a better COD removal capacity compared to a same size granular activated carbon (GAC) filter. After 10 L loading of fish wastewater GAC filter showed only 50% removal where as it was 90% for PACP filter. PACP filter did not reach to the breakthrough level or exhausted after continuous loading of 35 L of fish wastewater. Filtered PACP filter wastewater was used for rearing tilapia fish and up to the fourth water changing with a 48 hour interval, the fish was in good condition and no death occurred.

*Key words: PACP filter, fish wastewater, GAC filter.*

## INTRODUCTION

Water quality is a very important criterion for aquatic life. Among the aquatic lives fish is more sensitive towards water quality of the system. Therefore ensuring that fish have high quality water to live in is essential [1]. Water must be free of toxins. Toxins can be present in the water supply and they can also be produced by the fishes themselves as waste products of their metabolism. Different processes are followed to remove particular type of toxins from the water and make it suitable for fish culture before fishes are exposed to that water[1,2].

Factors controlling the composition of the natural waters are extremely varied and include physical, chemical and biological processes. The most important factors affecting the growth and survival of fish include the availability of food organisms, and the influence of naturally occurring substances such as temperature, pH, dissolved oxygen (DO), ammonia and nitrite, phosphate, turbidity etc[2].

In recent years aquaculture production has increased worldwide mainly due to the demand of the aquaculture produce and the need for new food supplies. Aquaculture systems have to consider the effects of the system discharge on the environment. To treat the water before discharge involves expenditure which may affect the economic viability of the system. In the long term perspective aquaculture industries cannot indiscriminately discharge nutrient enriched waters without any treatment. The solutions to the problems posed are based on minimising the nutrient loading rather than complete elimination[3].

Most of the work so far reported regarding the reduction of the pollutant from fish culture was mainly emphasising on the food habit and conversion of the feed to control the nutrient in the water. Some of the work was done to reuse the water through re-circulating system consist of bio-filter to remove the organic nutrient[4,5]. Nitrite and ammonia, two toxic elements, were removed from aquatic waste using electrochemical method [6]. Aquaculture has an effect on the environment such as pollution, landscape modification and biodiversity change. Excess fish food and fish excretion gives rise to suspended organic materials or dissolved organic such as carbon, phosphorous and nitrogen [7]. A significant but not dangerous pollution was observed in the area with ammonia and suspended solids being the most significant pollutants [8]. To reduce nitrogen loading from aquaculture a better feed conversion is essential as has been reported in many cases. It has been suggested that improvement in feed quality and technique can result in reduction in nitrogen pollution in aquaculture[4,9,10,11].

Present study focused on the use of PACP filter[12], which was developed in our laboratory, for the treatment of fish waste water and reuse of the treated water. Different water quality parameters were monitored such as COD, nutrients, turbidity and suspended solids. Further comparative study of PACP and GAC filter was also performed based on these parameters.

## METHODOLOGY

Unless and otherwise stated all the chemicals used for this study were of analytical grade. PAC and GAC used were of commercial grade. The instruments used for this study were HACH DR-2000 spectrophotometer for all spectrophotometric measurement. Glass aquariums of the size 30 cm height 25 cm width and 60 cm length were used for rearing the fishes. Aquarium aerator was used for aeration purpose. HACH[13] method was adopted for the measurement of COD. APHA[14] methods were used for other water quality parameters like nutrient turbidity and suspended solids.

**Fishes used for the study**

Tilapia fish fries (*Oreochromis niloticus*) were obtained from the fish house of the School of Biological Sciences, USM. Commercial fish food was obtained from local sources with a composition of minimum 32% crude protein, maximum 11% moisture, minimum 4% crude fat and maximum 8% crude fibre.

**Preparation of PACP and GAC filter**

The PACP filter used in this study was compared with conventional granular activated carbon (GAC) filter. Powdered activated carbon pellet (PACP) filter was prepared following the procedure described by Mohd. Asri *et al.*[12]. The size of the pellet obtained was approximately 0.5-1 cm. Perspex containers with the size of 15 cm in length 15 cm in width and 50 cm in height as shown in Figure 1 were used to prepare the filter. The bottom layer was filled with coarse sand (0.5-1 cm) up to 7 cm. The PAC pellets were then compactly packed, on top of the coarse sand layer. The pellet height was 30 cm. Another 4 cm layer of coarse sand (2-3 mm) was placed on top of the pellet layer. The water height was always maintained 2 cm above the top layer of the sand in order to prevent drying of the filter. Another filter was prepared following the same way except, for same amount of granular activated carbon (GAC) was used as a filter medium instead of powder activated carbon pellet. The schematic diagram of the filters is shown in Figure 1.

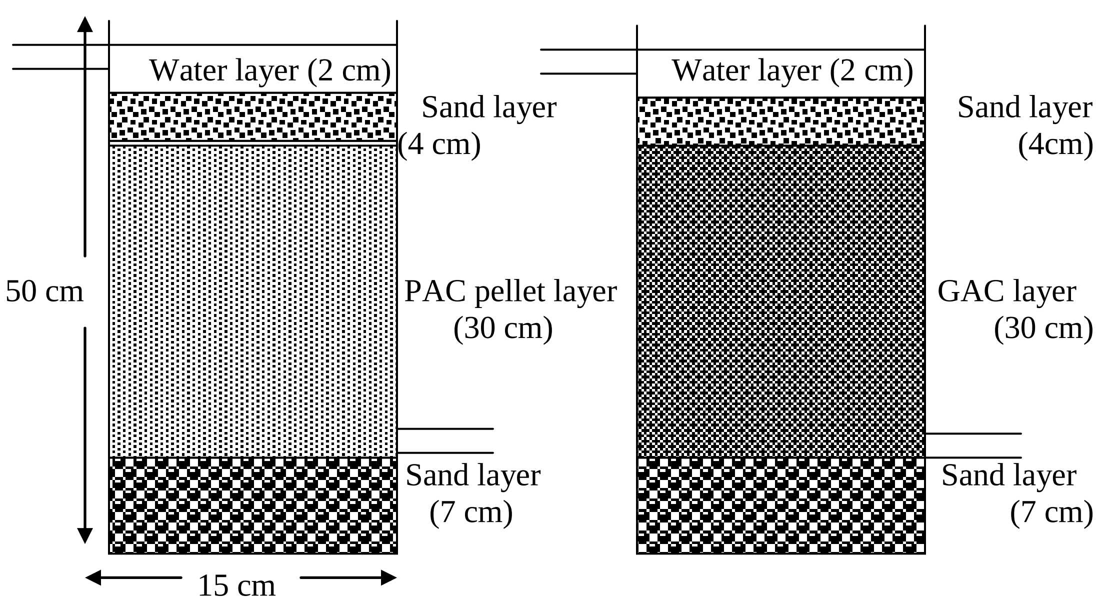


Figure 1. Schematic diagram of PACP and GAC filter.

**RESULT AND DISCUSSION**

Activated carbon powder is a good adsorbing material capable of removing various types of pollutants from the wastewater including organic substances. However, use of activated carbon in powder form is not practical as it is not that easy to separate from the water after treatment. Therefore, most of the time granular form of activated carbon is used. The surface area of granular form is much lower compared to the powder form, hence the efficiency is not as good as powder activated carbon form. Mohd. Asri *et al*.[12] had proposed a filter medium prepared from activated carbon powder by palletising it with latex. It was found that this pellet was capable of removing more than 95% COD from the domestic wastewater in a laboratory scale study.

Optimisation of the flow rate of PACP filter was done using waste water passing through PACP filters. Figure 2 shows the flow rate study of the waste using the PACP filter. It could be seen 50 ml/min and 100 ml/min flow rate showed over 90% removal with continuous load of ten litre wastewater. When the flow rate was increased, then it was observed that the removal efficiency dropped with the wastewater loading. For 120 ml/min, the removal dropped to 84% after ten litre of waste passed through the filter. For 150 ml/min, the removal became 78% after passing thorough ten litre of waste. The reason of the reduction of COD with higher flow rate is due to the shorter retention time of the wastewater inside the filter column. Usually, organics causing COD are removed by filter through adsorption. If the retention time is lower, than the contact time between the pollutant and the adsorption site become less, thus results in a poor removal.

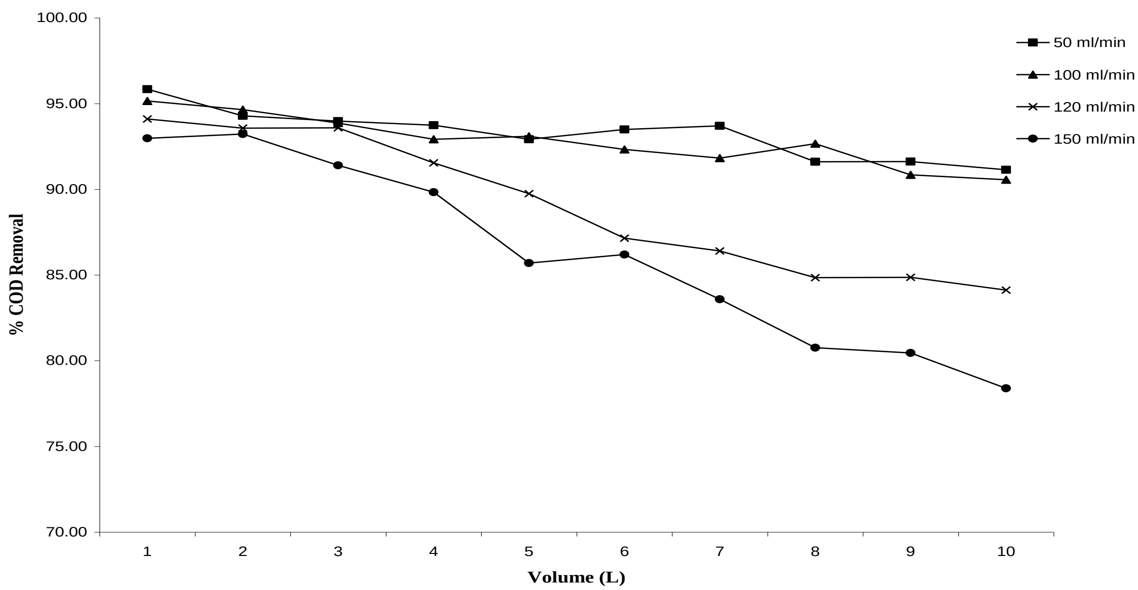


Figure 2: Percentage COD removal from fish waste water by PACP filter at different flow rate.

That was the main reason the percentage removal of COD with higher flow rate of 120 ml/min and 150 ml/min were lower compared to slower flow rate. For the flow rate of 50 ml/min and 100 ml/min, contact time of the waste was longer so the removal of the organic was higher causing a higher percentage of COD removal. As 50 ml/min and 100 ml/min were showing a comparable COD removal so 100 ml/min flow rate was selected as the optimum flow rate for the PACP filter. The maximum flow rate of the PACP filter was found 900 ml/min to 950 ml/min. This was one of the advantages for

PACP filter. The hydraulic conductivity was much higher and thus it would be possible to generate more treated wastewater within short period of time by increasing the flow rate and efficiency of the pollutant removal could be achieved by putting few filters in series. There was no leaching of the activated carbon pellet particles, observed during the study.

| **Parameters** | **Fish Waste Water** | **PACP filter Treated Fish Waste Water** | **GAC filter Treated Fish Waste Water** |
|---|---|---|---|
| Turbidity (FTU) | 22 | 6 | 11 |
| Suspended solids (mg/L) | 15 | 2 | 3 |
| COD (mg/L) | 125 | 10 | 65 |
| $NH_3$-N (mg/L) | 1.95 | 0.23 | 0.87 |
| $PO_4$ (mg/L) | 1.18 | 0.08 | 0.15 |

Table 1: Comparative water quality results of the fish waste water before and after filtering with PACP filter and GAC filter.

PACP filter was further studied to compare with GAC (granular activated carbon) filter prepared following the procedure described earlier. Both PACP and GAC filters were evaluated by monitoring the relative percentage COD removal from the fish waste water. In Figure 3, fish wastewater treated with PACP and GAC filter on the basis of percentage COD removal is shown. It showed a very clear difference between the removal capacities of two filters. PACP filter showed a 90% removal at the end of ten litre of wastewater loading. Whereas in case of GAC filter for one litre waste loading it showed only about 66% removal. After ten litre wastewater loading, it showed only 50% removal of the COD from the wastewater. From this result, it was very clear that GAC filter has a lower removal capacity compared to the PACP filter. In terms of total surface area, GAC has a lower surface area compared to powder activated carbon. PACP filter media was prepared from powdered activated carbon so it had a higher surface area for adsorption compared to GAC. For the GAC filter, the adsorption of the waste was mainly on the surface of the GAC. The GAC filter was reaching the exhaustion limit faster compared to PACP filter by loosing its active adsorption site. From the results of this experiment, it was conclusive that PACP filter was much efficient compared to GAC filter for treating fish wastewater.

Beside the COD the nutrient like ammonia nitrogen and phosphate showed a better removal using PACP filter. After loading of ten litre of fish wastewater the PACP filter showed about 90% removal of the ammonia nitrogen from the waste. After ten litre of waste loading the removal was maintained at 85%. Where as, the GAC filter showed a removal of about 70% of ammonia and after ten litres of waste loading the removal maintained at 60%.

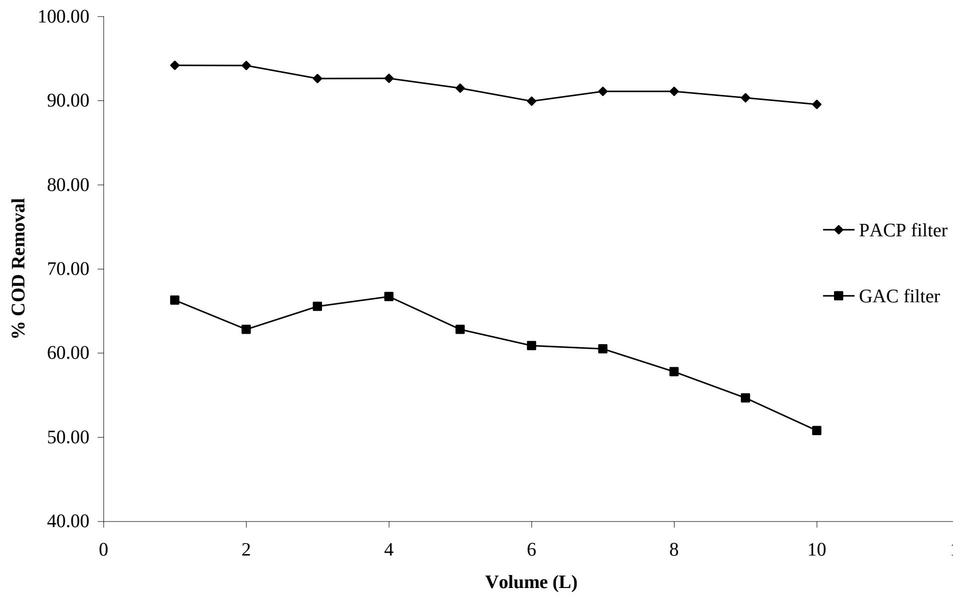


Figure 3: Comparative percentage COD removal from fish waste water by PACP filter and GAC filter.

Figure 4 shows comparative nutrient removal from fish waste water by PACP filter and GAC filter. In terms of phosphate the removal with PACP filter was 95% at the beginning and it remained at 93% after ten litre of waste loading. For GAC the removal was better than ammonia nitrogen it was 90% at the beginning but remained at 84% after ten litre of waste loading.

Similar result was also observed for the suspended solids and turbidity removal from the waste water. It was found that after passing through the filter the water become clearer because of reduced turbidity and suspended solid. The turbidity and suspended solids of the PACP filtered water was 6 FTU and 2 mg/L. For GAC treated water the values were 11 FTU and 3 mg/L respectively. A comparative water quality results before and after passing the fish waste water through PACP and GAC filter is given in Table 1.

It was found that PACP treated fish wastewater was having a water quality with a very low residual COD and nutrient that is suitable for reuse in fish culture purpose[15]. Tilapia fish fries were reared using the PACP filter treated fish waste water. After consecutive fourth water change with an interval of 48 hours, the survival of the fish was found 100% in the fish tank. It was proven from these experimental results that the PACP treated fish wastewater was safe for the tilapia fish and it did not have any toxic or other adverse effects on the fishes. From this result, it was concluded that PACP treated fish wastewater was suitable for reuse in fish rearing.

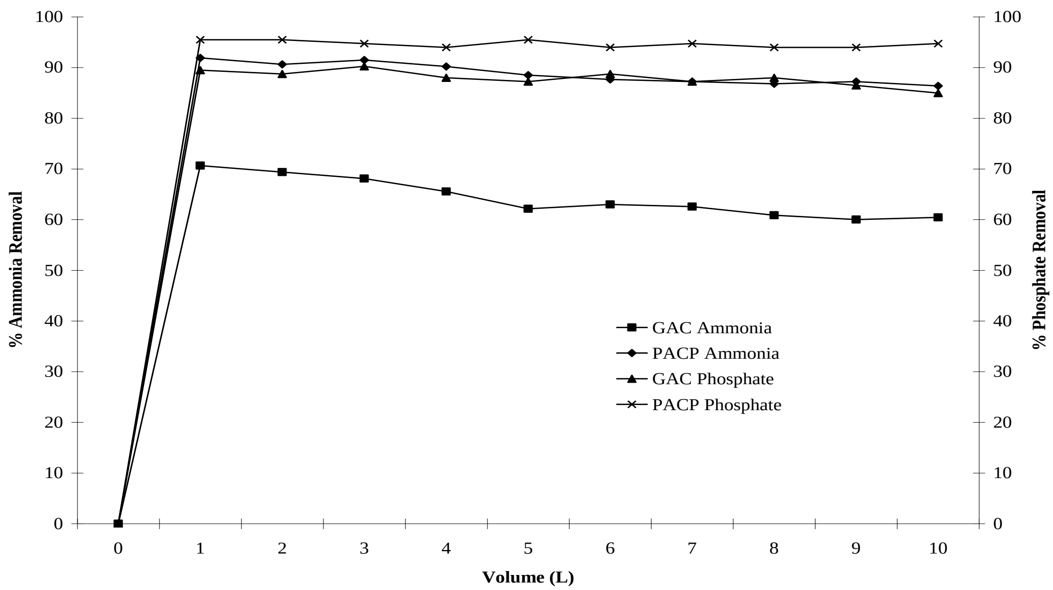


Figure 4: Comparative percentage ammonia and phosphate removal from fish waste water by PACP filter and GAC filter.

Breakthrough is the limit of the filter to remove at least 50% of the pollutant with a continuous loading of the waste. This defines the efficiency and the longevity of the filter column. Based on this result, bigger filter of the same type to treat similar type wastewater could be prepared. It was found that the PACP filter was able to remove about 90% COD until twelve litres of control wastewater loading. Then the removal rate reduced to 80% until twenty four litres of wastewater loading. After thirty five litres of wastewater loading, 65% removal of COD was possible with PACP filter. From the result it was found that until thirty five litre of wastewater loading the filter was not exhausted and it did not reach the breakthrough level. It was also found that the filter was showing a similar performance for several times with an interval of 48 hours. This result was almost consistent for consecutive seven time of use of the PACP filter. This trend of the self-regeneration of the filter was also found by Asri *et al*.[12] using powder activated carbon pellet for the COD removal. In this case, the effective removal of the COD from fish wastewater by PACP filter was not very unusual based on the result found by them.

## CONCLUSIONS

PACP filter developed and studied in our laboratory was very effective for the removal of organic and nutrient from the fish wastewater. This filter was able to produce filtered fish wastewater having a water quality suitable for fish rearing. It showed a very good water quality in terms of organic and nutrient removal. From comparative study of PACP filter with GAC filter, it was found that PACP filter was more effective than GAC filter. GAC filter after passing through few litre of fish wastewater the organic removal efficiency dropped drastically almost to 50% whereas for the PACP filter, 90% COD removal was possible from the fish wastewater after ten litre of effluent loading. PACP filter has efficiency of removing organic up to thirty five litre of fish wastewater loading. It was also found that PACP filter could self-regenerate with a resting period of 48 hours. It could regain its efficiency for the removal of organic and nutrient up to 90% with a resting period of 48 hours. PACP filter could be a good bio filter system for reuse of the fish wastewater. Filtered water using the PACP filter was suitable for fish rearing as it met the water quality criteria for the fish culture. Using the PACP filtered fish wastewater, tilapia fish was reared and 100% survival of the fish was observed until four times of water change. This result proved the efficiency of the treatment system.

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