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EFFECT OF ELECTRON BEAM IRRADIATION ON FISHERIES WATER

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ABSTRACT

This paper studies about water obtained from fish pond of fisheries research centre. Usual water quality parameters such as pH, COD, Turbidity and Ammonia content were analyzed before and after irradiation. Electron beam irradiation was used to irradiate the water with the dose 100 kGy, 200 kGy and 300 kGy. Only high dose was applied on this water as only a limited amount of samples was supplied. All the parameters indicated a slight increase after irradiation except for the ammonia content, which showed a gradual decrease as irradiation dose increases. Sample condition was changed before irradiation in order to obtain more effective results in the following batch. The water sample from fisheries was diluted with distilled water to the ratio of 1:1.This was followed with irradiation at 100 kGy, 200 kGy and 300 kGy. The results still showed an increase in all parameters after irradiation except for ammonia content. For the following irradiation batch, the pH of the sample was adjusted to pH 4 and pH 8 before irradiation. For this sample the irradiation dose selected was only 100 kGy. A higher value of ammonia was observed for the sample with pH 4 after irradiation. Other parameters were almost the same as the first two batches.

Keywords: BOD, COD, electron beam irradiation, fisheries water, turbidity

INDRODUCTION

The water used for this study is from the fish pond of fisheries research centre. The main problem faced by the marine researchers is the high content of ammonia (NH_3) in pond water. The toxicity of ammonia is one of the biggest killers of pond fish. The effects of high ammonia content in water, over a long term, are eutrophication, offensive odors and hinder the disinfection of water supplies. Water used for fish breeding and farming is stemmed from rivers. The waste from the chemical industries along the rivers might contribute to the higher content of NH_3 in the water. Due to this circumstance, there is a need to find a solution to reduce the content of NH_3 in the ponds, using very efficient and effective ways.

Several methods have been developed for the removal of ammonia from water including biological nitrification, stripping, ion exchange, break-point chlorination and chemical precipitation (Delwhich, 1981). Unfortunately, each of these methods has its own disadvantages. Biological nitrification produces acid which lowers the pH of biological population. Due to high toxicity of acid, the growth of nitrifying bacteria reduces. Ammonia stripping method produces ammonia sulfate as a by-product which in turn, needs to be disposed of. This is very costly. Electron beam radiation treatment might be useful to reduce the ammonia content in water since radiation technology has been used to enhance the biodegradability of wastewaters containing various biologically refractory organic compounds such as textile wastewater, landfill leachate, paper mill wastewater and effluent from petroleum production (Duarte et al., 2004).

Wastewater treatments using ionizing radiation such as gamma and electron beams have been studied and the decomposition of many organic compounds in aqueous solution have been reported (Kim et al., 2007). Ionizing radiation will not produce secondary polluted materials. Hence it's considered as one of the promising method (Bae et al., 1999).

Ionizing radiation is known as radiation that has sufficient energy to dislodge electrons from atoms and molecules and to convert them to electrically-charged particles called ions. Further reactions of these species, will lead to the formation of free radicals which are usually reactive and that eventually will lead to chemical reactions (Dahlan, 2001). In this paper, the effect of electron beam irradiation on fish pond water has been studied. The water was irradiated at selected doses and the properties of the irradiated water were examined.

MATERIALS AND METHODS

Sampling and Sample Preparation

Water used in this research was obtained from Aquamarine Culture Technology Centre, FRI Gelang Patah. Sampling was done by the fisheries research centre. The sample was from fish pond where activities such as fish farming and breeding are being carried out. Water supply for the fisheries centre ponds comes from river. The river water was subjected to the sedimentation process and chlorine treatment prior to being supplied to the entire pond.

Water samples for these studies were prepared in three batches. The first batch of samples was sent to irradiation without any modification. The sample in the second batch was diluted with distilled water to the ratio of 1:1 before irradiation. The pH of the sample was adjusted to pH 4 and pH 8 for the third batch before irradiation.

Irradiation

Electron beam irradiation, samples were filled in a tray and placed on the trolley, then transported to the irradiation chamber in order for the samples to be irradiated. According to the speed of conveyor and current (mA) of applied electron beam, the dosages of irradiation were adjusted. Irradiation of samples was conducted using Nissin, 1 MeV and 30 mA in a batch system. The speed of the conveyor was adjusted according to the doses required and the sample thickness was 3.0 mm. The irradiation doses selected for batch one and batch two samples were 100 kGy, 200 kGy and 300 kGy. Meantime, the irradiation dose selected for batch three samples was 100 kGy.

Sample Analysis

Samples were analyzed before and after irradiation. COD was determined using dichromate solution with digestion in a Hach reactor and followed by UV absorption measurement using a Hach-2400 spectrophotometer. pH of the sample was analyzed using a pH meter (WTW Multi 340i). Hach DR 5000 spectrophotometer were used for color measurement. Turbidity was determined using Hach 2100 P turbidimeter. Nitrogen, ammonia using salicylate method was used to measure ammonia content.

RESULTS AND DISCUSSIONS

Effect of Irradiation on pH

The original pH of unirradiated sample was 7.44. For batch one samples, the lowest pH obtained for sample irradiated at 100 kGy was 7.26. pH of sample irradiated at 200 kGy was higher than the unirradiated sample. The pH of sample irradiated at 300 kGy was almost the same as that of the unirradiated sample. pH of unirradiated sample for second batch was 7.52. After irradiation the pH of samples reduces and the lowest pH recorded was 7.39 for sample irradiated at 200 kGy (shown in Fig. 1.). The pH of third batch samples was intentionally adjusted to pH 4 and pH 8 to study the effects on other parameters. Conversion between NH_3 and NH_4 exist in an equilibrium relationship with the pH. The lower pH, the lower concentration of highly toxic NH_3 and the higher concentration of the less toxic NH_4 (Gorden, 2006). Thus, reduction in pH indicates formation of NH_4 after irradiation.

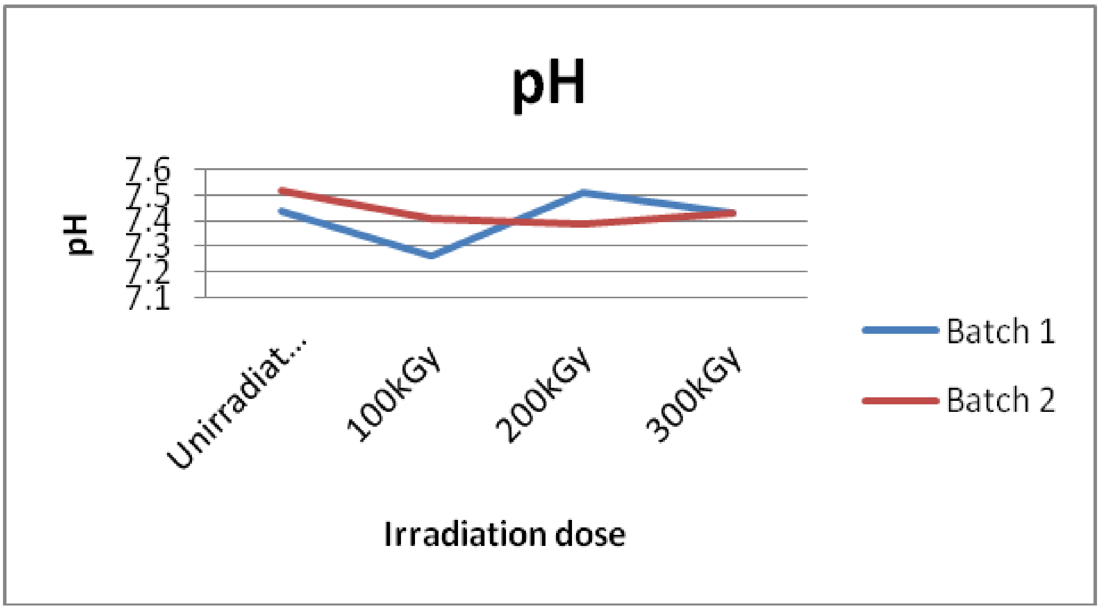

Figure 1: Effect of on pH

Effect of Irradiation in Removal of COD

COD was used to indicate the aggregate amount of organic matters present in wastewater and determine the quality of water (APHA, 2005). COD measurement is based on theoretical amount of oxygen required to oxidize organic compound to CO_2 and H_2O. The COD of batch one sample which was irradiated at 300 kGy increases 19.6%. COD of sample irradiated at 300 kGy in batch two also increases 5.67% as shown in Fig. 2. COD of batch three samples was 57.5 mg/l for pH 4 and 39.25 mg/l for pH 8. COD of both samples increases compare to COD of sample with original pH which is shown in Fig. 3. Ionizing irradiation of water will lead to the formation of free radicals as follows (Woods and Pikaev, 1994).

$$H_2O \longrightarrow {}^{\cdot}OH + H^{\cdot} + e^-_{aq} + H2 + H_2O_2 + H_3O^+$$

Hydroxyl radicals are the main reactive species responsible for the decomposition of pollutants. The higher the dose, more OH radicals are produced and hence more degradation of pollutants are expected.

$$^{\cdot}NH_3 \quad + \quad ^{\cdot}OH \longrightarrow NH_2 + H_2O$$
$$^{\cdot}NH_2 \quad + \quad ^{\cdot}OH \longrightarrow NH_2OH$$

But at higher concentration, pollutants will remain in an incomplete decomposition condition. Moreover the breakdown of pollutants to simpler or smaller form after irradiation may contribute to increase in COD value after irradiation (Ming and Dahlan, 2011).

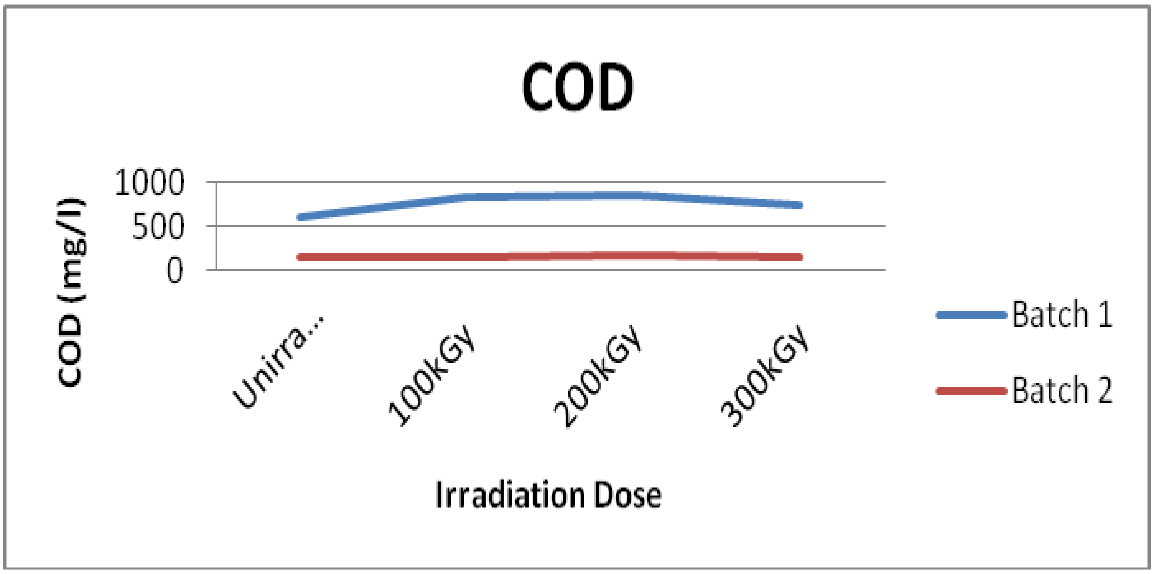

Figure 2: Effect of on COD

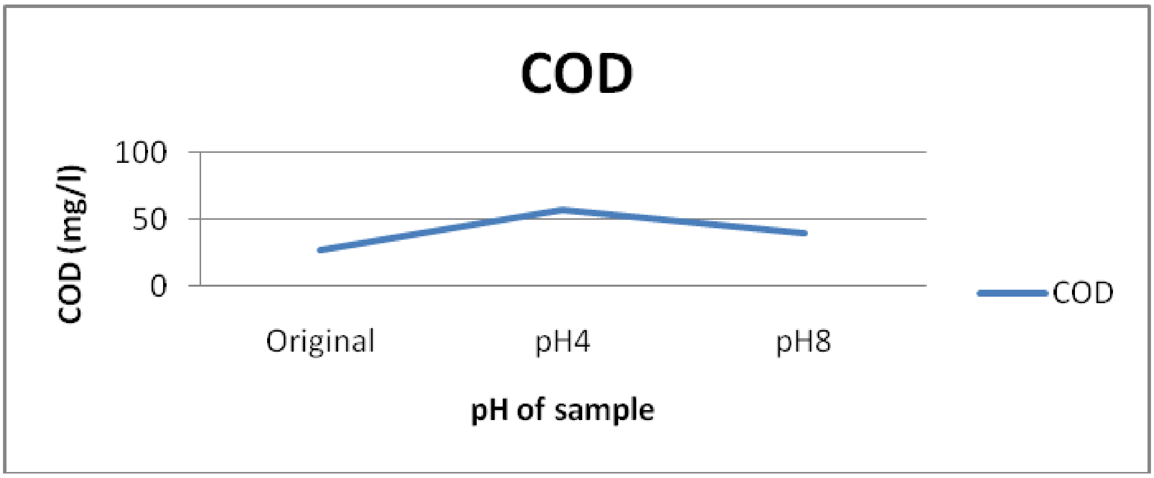

Figure 3: Effect of on COD at different pH

Effect of Irradiation on Turbidity

Turbidity is the cloudiness of a liquid caused by individual particles (suspended solid). Turbidity of unirradiated sample for batch one was 2.00 NTU. After irradiation at 100 kGy it increases to 2.30 NTU. The increase in turbidity is due to the formation of very small particles which will settle only very slowly and cause the liquid to appear turbid and causes turbidity to increase after irradiation 100 kGy. Samples irradiated at other doses showed no significant changes. For batch two samples, the turbidity increases at 300kGy up to 1.22 NTU (shown in Fig. 4). Turbidity for pH 4 and pH 8 of batch three samples reduced compared to sample with original pH (shown in Fig. 5). Changes in turbidity indicate degradation and decomposition of pollutants.

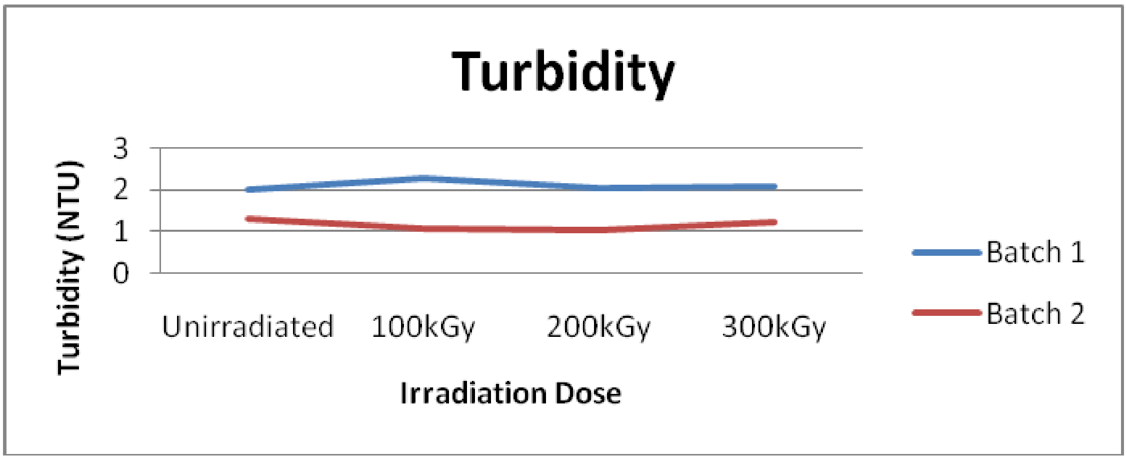

Figure 4: Effect of on Turbidity

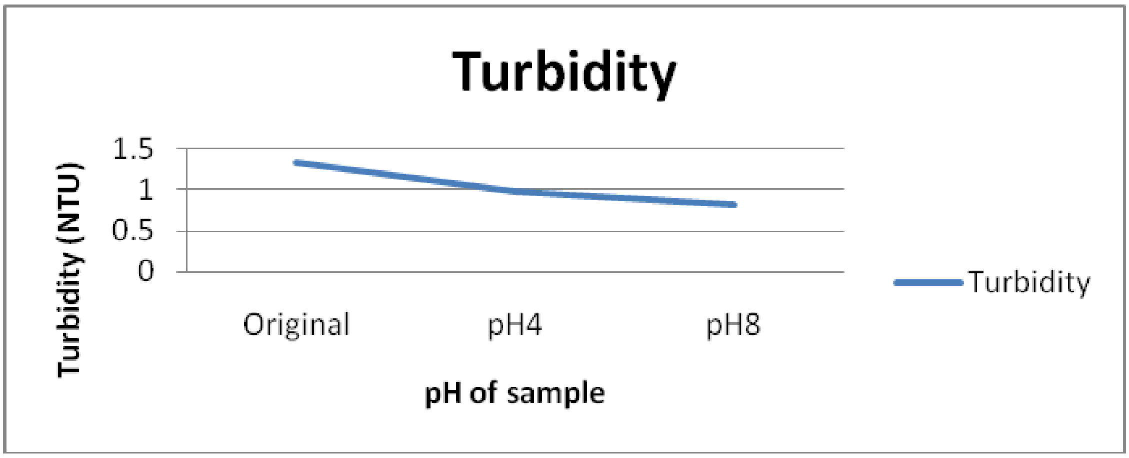

Figure 5: Effect of on Turbidity at different pH

Effect of Irradiation on Removal of Ammonia

Ammoniacal Nitrogen (NH_3-N) is a measure for the amount of ammonia, a toxic pollutant, often found in wastewater. For both batch one and two samples, ammonia reduces after irradiation (shown in Fig. 6). However, ammonia increases for pH 4 sample compared to the original samples. A slight reduction of ammonia was observed in pH 8 samples (Fig. 7). Ionizing irradiation of water will form free radicals which lead to reduction of ammonia in water. The high dose would result in higher reactive radicals formed, but leads to the increase of radicals-radicals recombination involving **$^{\cdot}$OH, H$^{\cdot}$** and **e^-_{aq}** (Buxton et al., 1988).

$$^{\cdot}OH + e^-_{aq} \longrightarrow OH^-$$
$$^{\cdot}OH + H^{\cdot} \longrightarrow H_2O$$

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As dose increases, the competition of radical's reaction in radicals-radicals recombination reactions and radicals-solute reactions leads to lower removal efficiencies. The same phenomena will occur when pH of water is adjusted to pH 4 and pH 8 whereby more radicals are provided at higher dose and this may lead to increase in ammonia after irradiation.

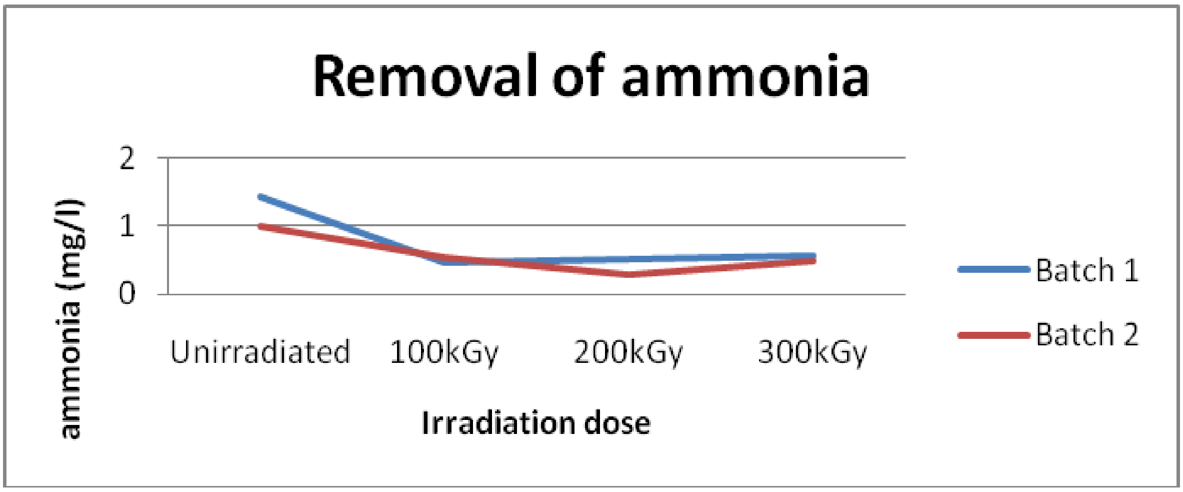

Figure 6: Effect of on removal of ammonia

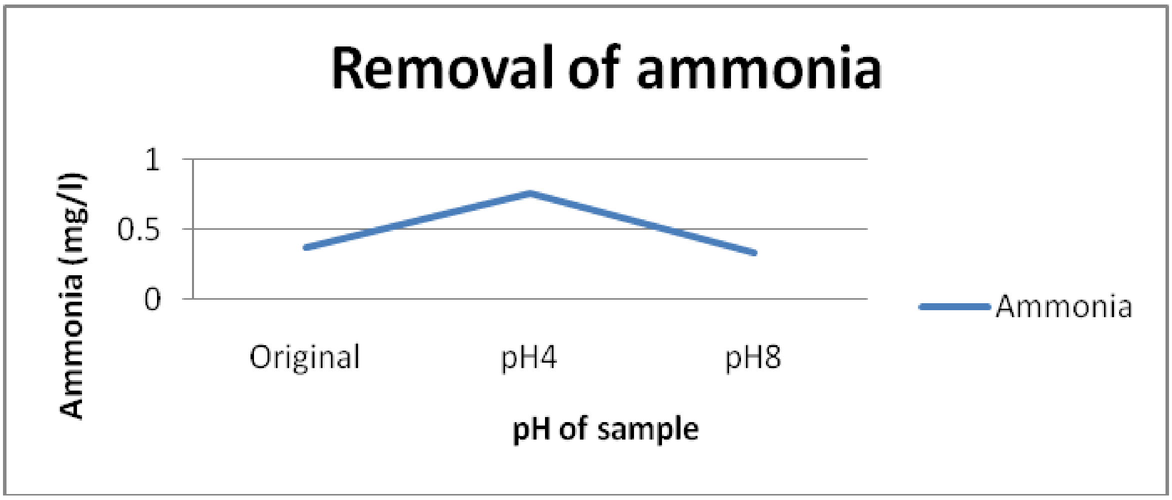

Figure 7: Effect of on removal of ammonia at different pH

CONCLUSIONS

Irradiation by electron beam aims to destroy the ammonia in water. But it the outcome wasn't that satisfactory. Maybe in future low irradiation doses might be used with combination with conventional method such as biological treatment would produce most effective results.

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