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Application of Aquaponic System as an Alternative for Medical Liquid Waste Containing Blood at the Dentist's Practice

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ABSTRACT

The waste generated by the dentist clinic is in the form of non-medical waste and medical waste. Medical liquid waste containing blood can develop disease if not processing properly before entering the environment. Aquaponic system is a combination of hydroponics and aquatics, also the resirculation process using plants and animals as: convolvulus land (Ipoema Reptans) and catfishes (Clarias spp.) that able to survive the extremes. Aquaponic system has potential to be an alternative to treating medical liquid waste containing blood according to medical liquid waste standard in Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014. The study aims to observe the value changes of the liquid waste parameter as: BOD, COD, TSS, pH; and compare them to medical liquid waste standard. The research is a pre-experimental on shot case study that done in four days and put the treatment on the first day then the sample were taken every 24 hours. The measurement result of the liquid waste parameter has an efficiency as: BOD 57, 1%, COD 40 %, TSS 53 %, and pH 4, 7 %. All the parameter not exceeding the medical liquid waste standard in Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014. The conclusion is the application of an aquaponic system can be used as an alternative to medical liquid waste containing blood treatment

Introduction

Waste is a by-product of an activity that is no longer used (Kemensetneg RI, 2009). The waste generated by dentist clinics is in the form of non-medical waste and medical waste (Putri et al, 2018). Medical waste is waste from medical efforts in the form of hazardous toxic materials (B3) such as syringes, masks, patient mouth rinses, and blood waste. Dentist clinics produce 8.86% infectious waste every day and 90% of 110 dentist clinics dispose of it into the environment without treatment (Andaei et al, 2014). Meanwhile, the liquid medical waste contains blood that can transmit diseases such as hepatitis and HIV/AIDS through the pathogens in it (Purwanti, 2018). If this disposal is carried out continuously it will be harmful to the environment. The presence of disease-causing pathogenic bacteria and increases in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Susppended Solid (TSS), and Potential of Hydrogen (pH) values can contaminate the environment (Andaei et al, 2014).

Liquid medical waste treatment is also required to meet the liquid waste quality standards in the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 which consists of BOD, COS, TSS, and pH. Limited costs at dentist clinic health facilities mean that liquid medical waste cannot be processed using a Wastewater Treatment Plant (WWTP) such as in hospital health facilities (Putri, et al, 2018). These obstacles need to be overcome by developing wastewater treatment technology as an alternative to treat liquid medical waste quickly and inexpensively. The aquaponics system can be one of the main choices to overcome this problem (Maharani and Sari, 2016).

The aquaponics system is a combination of hydroponic and aquaculture techniques (Patillo, 2017). The aquaponics system implements the Recirculating Aquaculture System (RAS), in which wastewater from the aquarium is flowed through pipes and naturally filtered by plants to remove solids, ammonia, CO_2, and other content in the waste (Panigrahi et al, 2016; Thorarinsdottir, 2015). Kale plants are commonly used for aquaponics, kale will absorb toxic substances contained in its environment (Putri, et al, 2019). Water spinach acts as a phytoremediation that can decontaminate waste in water (Haruna et al, 2012). Chemical elements contained in the blood such as phosphate, urea, amino acids, and sodium ions will be absorbed and become nutrients for plants (Ernawati et al, 2015). While the fish used are freshwater fish such as catfish because they can adapt to extreme environments (Putri et al, 2019).

Based on these problems, an alternative effort is needed to treat liquid medical waste containing blood by utilizing the working principle of the aquaponic system. This study aims to observe changes in the parameter values of liquid waste quality standards (BOD, COD, TSS, and pH) and compare them with hospital wastewater quality standards in the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014.

Methods

This type of research is pre-experimental with a one-shot case study research design. The experimental unit for this research was water in a glass aquarium measuring 40 x 25 x 15 cm using the grab sample technique. The research was conducted in August 2020 at the Physiology Laboratory, Faculty of Dentistry and Environmental Control and Conservation Engineering Laboratory, University of Jember. The total samples in this study were 16 samples consisting of 4 parameters, namely BOD, COD, TSS, and pH without repeating. Samples were taken 4 times, namely in the aquaponics system which had worked for 0 hours (A1), 24 hours (A2), 48 hours (A3), and 72 hours (A4) of 500 mL.

The research begins with making ethical clearances and preparing water installations. The preparation of the water installation is done by connecting 3 pipes with a length of 3.5 cm, 20 cm, and 36 cm respectively with a diameter of 1.5 cm. The series of pipes are connected to a water pump and arranged in an aquarium containing 5 albino catfish with 10 L of water then covered with a plant container on top. The Ipomea Reptans p. plants are placed in a net pot then filled half full with rock wool then coral until it fills the plant container. The aquaponics system was given treatment in the form of 2 mL of blood and then sampling was carried out. Furthermore, water quality measurements were carried out with the parameters BOD, COD, TSS, and pH according to procedures at the National Standardization Agency, and then data analysis was carried out.

Results and Discussion

Results

The research results obtained were in the form of a change in the color of the aquarium water to reddish shortly after being treated, then gradually faded and returned to clear. No dead albino catfish or loss of appetite. Growth occurs in water spinach plants with an average growth height of 7.3 cm. The Ipomea Reptans p. leaves turn yellow.

Table 1. Results of Measurements of Water Quality Parameters (BOD, COD, TSS, pH)

Water quality parameters	A1	A2	A3	A4	Maximum limit
BOD	48,7	41,75	34,79	27,83	50 mg/L
COD	52	37	47	31	80 mg/L
TSS	13	10	8	6	30 mg/L
pH	8,5	8,4	8,1	8,8	6-9

The results from Table 1 shows that the COD parameter experienced the most fluctuating value compared to BOD and TSS which tended to decrease, the pH parameter also showed results that tended to decrease but experienced an increase in sample A4. No parameters show results exceeding the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014.

Discussion

The results of the study showed that the highest BOD value was in sample A1 because of the presence of the effect of solutes on the blood introduced into the aquarium. Blood causes the BOD content to increase due to the presence of solutes in it (Subadyo, 2017). Blood contains dissolved organic matter, namely: albumin, sodium, chlorine, phosphate, and calcium in blood plasma (Faranita et al, 2016). Organic materials are food for aquatic microorganisms that can trigger their growth. Aquatic microorganisms need oxygen to degrade organic matter in water, this oxygen demand is expressed as BOD (Handayani and Evita, 2018). The addition of blood to the aquarium causes the content of organic matter in the water to increase so that the oxygen demand also increases and makes the BOD value high.

The BOD value decreased by 42% in sample A4 due to the kale plant as a phytoremediator. The kale plant is a plant that is relatively resistant to various kinds of contaminants and accumulates them in the tissues. This makes the kale plant act as a phytoremediator in the process of phytoremediation (Arsa et al, 2019). In phytoremediation, wastewater treatment occurs through a process of filtering and absorption of contaminants by the roots and stems of plants, as well as ion exchange and absorption processes (Khaer and Nursyafitri, 2019). After processing with the aquaponic system for 72 hours, the BOD value decreased by 57.1%. It did not exceed the quality standard for hospital wastewater in Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014.

The COD value shows quite fluctuating results. In sample A1, the highest COD value was due to the influence of solutes on the blood that was put into the aquarium. Blood causes the BOD content to increase due to the presence of solutes in it (Subadyo, 2017). Blood contains dissolved organic matter in blood plasma (Faranita et al, 2016). The COD value is defined as the amount of oxygen required so that the organic and inorganic waste materials in the wastewater can be oxidized through chemical reactions (Lumaela et al, 2013; Atima, 2015). Giving blood to the aquarium increases the organic matter content in the water. The more organic matter content in the water, the higher the need for oxygen to oxidize, this condition causes a high COD value. The COD value decreased by 28% in sample A2 due to the presence of water spinach which plays a role in phytoremediation. The COD value increased by 27% in the COD test results for sample A3 due to the fact of organic matter from catfish manure. Catfish produce excrement containing nitrogen ranging from 0.98-1.67%, phosphorus 1.89-3.40%, and potassium 0.10-1.03% which are organic matter. The addition of these organic materials to the water causes the COD test to produce an increase in COD value (Said and Lalla, 2020). The results of COD measurements in sample A4 showed a decrease of 34% due to the uptake of organic matter by plants. The aquaponics system utilizes organic matter from catfish waste for plant growth (Marlina and Rakhmawati, 2016). After processing with the aquaponic system for 72 hours, the COD value decreased by 40%. It did not exceed the quality standards for hospital wastewater in the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014.

The TSS value in sample A1 is the highest TSS value due to organic and inorganic materials in water treated with blood. TSS is affected by particles of organic and inorganic materials or both (Jiyah et al, 2016). The addition of this organic material comes from blood dissolved substances or fine sand from coral stones that are carried into water bodies (Arsa et al, 2019; Jiyah et al, 2016). In sample A4, the TSS value decreased to 53% from sample A1. This decrease is influenced by the growing media which acts as a filter for suspended solids so that the size of the gaps in the growing media that is flowing with water affects the removal of organic matter (Fitri et al, 2016) The planting medium used is rockwool which is made from a combination of basalt rock, limestone, and new rock which is heated at high temperatures (Fitmawati et al, 2018). The heated rock wool produces a fiber with a cavity of about 6-10 μm which can retain a good amount of water and air to support the filtration of an aquaponic system (Alvian, 2015). The presence of suspended solids filtered into rock wool is what makes the TSS value lower than before. Using an aquaponics system as an alternative to treating medical waste in the form of blood has reduced the TSS value by up to 53%.

The last parameter measured is pH. The pH value in this study was in the range of 8.1-8.8. The pH value indicates that the water is weakly alkaline which are ideal conditions for aquatic animals (Arizuna et al, 2014; Qalit and Rahman, 2017). The pH values in samples A1, A2, and A3 tended to decrease due to the photosynthesis process. During photosynthesis, plant roots absorb positive ions, so plants secrete positive ions (H^+) into the environment. This increase in H^+ ions causes the pH value to decrease (Apsari et al, 2018). However, in sample A4 the pH value increased to 8.8 from sample A3 with a result of 8.1 due to the presence of ammonia in catfish feces. Catfish excrete 80-90% of ammonia through the osmoregulation process, while from feces and urine around 10-20% of the total nitrogen (Marlina and Rakhmawati, 2016). Ammonia is also produced from the process of degradation of organic matter by aquatic microorganisms (Dwi et al, 2018). This causes the pH value to increase which indicates that the water in the aquarium is weakly alkaline. Even though the pH value in this study increased when taking A4 samples, the aquarium water has undergone treatment and contains less organic matter, so it tends to be safe to be discharged into the environment. Changes also occur in the aquaponic system, a reddish color is seen in the water in the aquarium. This color change is due to the presence of heme in hemoglobin which is released from oxygen when it is in water (Mallo et al, 2012). Heme that is released from oxygen will have a darker color and cause a reddish color in aquarium water (Putri et al, 2019). Furthermore, the appearance of foam on the surface of the aquarium water at 0 hours and 24 hours decreased at 48 hours and 72 hours. Foam can occur due to the presence of saponin-type glycosides which are shaken by water droplets from the pipe flow in the system. This shock causes saponins to turn into micellar compounds that have polar and polar sides, this is what is seen as foam on the surface of the aquarium water. Low levels of saponins can also lyse red blood cells so that the reddish color in aquarium water slowly fades (Agustina et al, 2018). The color of the water in the aquarium is getting clearer and clearer due to the recirculation process. In recirculation, organic and inorganic materials are transferred as a result of fish metabolism and liquid medical waste. So that the water that returns to the aquarium contains less organic and inorganic matter than before (Mulqan et al, 2017). In this study, no dead catfish were found. Catfish can survive in polluted waters because they have additional respiratory organs in the form of modified gill arches. This organ functions to absorb oxygen which allows catfish to breathe in humid conditions and a small amount of oxygen (Windriani, 2017). Changes also occurred in the height of the water spinach plant, which experienced an average growth of 7.3 cm per day. This is because kale plants utilize chemical elements such as phosphate, urea, amino acids, and sodium ions contained in human blood and fish waste as nutrients for plants. Some kale plants are seen experiencing yellowing leaves due to a lack of sunlight. Plants that lack sunlight experience etiolation, which turns yellow and has long but thin stems (Fadhlillah et al, 2019). Yellowing of the leaves of the kale plant can also be caused by a lack of absorption of nutrients. Yellowing leaves are a sign that kale plants are getting relatively few nutrients, so an additional fertilizer is needed for the growth of kale plants (Nastika et al, 2018).

CONCLUSION

Based on the research that has been done, the results of measuring the parameters of the liquid waste quality standards, namely: BOD, COD, TSS, and pH in the aquaponics system containing liquid medical waste in the form of blood tend to decrease, and do not exceed the maximum limit of the hospital wastewater quality standards in the Regulations. Minister of Environment of the Republic of Indonesia Number 5 of 2014. So it can be concluded that the application of the aquaponic system can be used as an alternative to treating liquid medical waste in the form of blood. This is the first time this research has been conducted, so an experimental study is needed. It is also necessary to conduct research using other aquaponic system techniques such as NFT and DWC and the use of other aquatic plants and animals such as ornamental plants and tilapia also needs to be carried out so that the aquaponic system can be utilized for a wider range of purposes.

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