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EFFECT OF FERTILIZER MATERIALS DERIVED FROM HOSPITAL WASTEWATER TREATED WITH BIODETOX TECHNOLOGY ON THE GROWTH AND YIELD OF CHINESE CABBAGE (*Brassica juncea* L.)

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ABSTRACT

The objective of the research was to analyze the wastewater of Sanglah General Hospital Centre (RSUP Sanglah), Denpasar Bali Indonesia using Biodetox technology and to study the responses of Chinese cabbage (*Brassica juncea* L.) to the product. The research was conducted from 15 May 2009 to 15 June 2012. Results of the research indicated that the technology using 7.2 hours day^{-1} aeration could reduce Biological Oxygen Demand (BOD) level to 88%, but increased the Food/Microorganism (F/M) ratio to 13.94 g/BOD/day/g/Mixed Liquid Suspended Solids (MLSS), shortened sludge age to 22.71 hours, lowered sludge recirculation to 23.25%, decreased pollutant levels to 0.6% MLSS and 78% TSS. Those results had met the quality standard for wastewater processing technology and for irrigation water respectively of Department of Health (Permenkes RI No. 416/MENKES/PER/IX/1990) and Department of Environment (Kepmen KLH No.02/MENKLH/I/1988) of Republic Indonesia. The characteristics of the wastewater (containing 1.97% N, 0.78% P, 0.33% S, 0.48% K, 0.19% Mg, 0.96 mg l^{-1} Fe, 0.08 mg l^{-1} Al, 0.11 mg l^{-1} Mn, 0.19 mg l^{-1} Mg and 0.22 mg l^{-1} Mo), had also met the quality standard for fertilizer materials (Hammer, 2001). The products of the technology have been proven to be safely used as fertilizer materials as indicated by no heavy metals contained and significantly 19.9% and 17.3% higher leaf and plant total fresh weights of Chinese cabbage, respectively compared to commercial Biosugih and Hyponex fertilizers at the rate of 15 g product pot^{-1}.

Key words: Sanglah General Hospital Centre, water quality,

INTRODUCTION

The limitation in availability of resources could be a problem in producing fertilizer. Hospital wastewater is one of alternative resource for fertilizer due to high contents of protein, carbohydrates and other minerals needed by plants. Besides, the wastewater is available abundantly. Liquid wastewater contains 99.0% water and 0.9% solid which consists of 65% protein and 25% carbohydrates and the rests are fats and several minerals (such as N,P, K, Mg, Ca, S, Na, Fe, Mn, Zn, Cu, B, Al, Mo). In addition, amino acids, hormones and microorganisms are found in liquid wastewater (Meagher, 2000; Askarian *et al*., 2004). According to Caldwell (2001) the materials for a save fertilizer should contain high proteins and carbohydrates. The processing of hospital wastewater like others will produce sludge. Vigneswaran and Sundaravadivel (2004) stated that sludge can be reused as soil conditioner and as a fertilizer in agriculture.

The technology for processing hospital liquid wastewater has been generally aimed at eliminating the pollutant only, but ideally it is supposed to maintain the beneficial components in it to be reused for other purposes. The Sanglah Hospital located in Denpasar, Bali Indonesia has recently been using the Biodetox technology for processing its wastewater, however there has been no study to prove that the technology has met the standard for the wastewater processing operational and the product has not been confirmed to meet the quality standard for fertilizer materials to be safely used for fertilizer.

The existence of organic materials in hospital wastewater indicated by parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD) and total suspended solid (TSS) (WHO,1989). The organic materials consist of bacteria, fungi, algae and protein and nitrogen rich solid materials. Ammonium, nitrates and nitrites are included in the wastewater as well. The contents of plant growth hormones (gibberellins, zeatin and IAA) that derive from fungi and higher plants are the other positive aspects of the hospital wastewater compared to the other organic fertilizers. Hospital wastewater also contains hormones, which are in the human and animal urines, that contain indoles. The combination of indoles with acetic acids becomes indole acetic acids with the role of promoting new shoots (Chitnis, 2003). The wastewater could be originated from medical and non-medical activities of the hospital. It has been well known that microorganisms involved in wastewater are Azotobacter sp., Azospirilium sp., Mycorrhiza sp., Rhizobium sp., Aspergillus sp., and Saccaromyces sp. (Martin *et al*., 2000). The criteria was also set up by FAO (1992) for the wastewater quality guidelines for agricultural use. To be safely used, the hospital wastewater should meet the standard set up for its usage (Pusstan, 2003). Therefore, a technology is required to process the wastewater biologically to produce fertilizer materials with biological and other safe contents for plants and environment. Sanglah General Hospital Centre (RSUP Sanglah) located in Bali Province of Indonesia, have been using Biodetox biological technology to refine its wastewater. The Biodetox technology uses biological principles as specific method, which is different from other technologies used in other hospitals in Indonesia. The product of that technology in the RSUP Sanglah has not been used so far for any particular purposes.

In the Biodetox technology there are four levels of processes involved viz. pre-treatment (in A pond), treatment (in B pond) and stabilization (in C pond) and disposition (in D pond) but the first three of them are very important in the technology (Figure 1). Decompositon, fermentation and mineralization activities occurred in each of level of the process and several types of microorganisms are involved in the activities, therefore biological treatments are needed to maintain the processes. Those treatments consist of adding oxygen (to promote the biodegradation process of organic materials), nutrients (to increase the growth and activities of microorganisms) and water pressure (sludge recirculation) (to optimalize pH, temperature and oxygen of the environment) (Sugiharto, 1987).

Nugroho (1996) reported that by giving an aeration treatment (250 HP aerator) of 10-20 hr/day on wastewater of 15,000 m^3/day with pH of 5.4, BOD of 500 ppm and Chemical Oxygen Demand (COD) of 900 ppm could maintain BOD of 2000-5000 ppm. Meanwhile, Murachman (2005) indicated that aeration treatment of 0.8-4.0 mg/l could increase the activities of microorganisms in the degradation process of pollutants and decrease the existence of methane, H_2S and CO_2 by 60%-80%.

The feasibility of RSUP Sanglah wastewater to be used as an alternative resource of fertilizer materials, could be determined through laboratory analysis of quality and characteristic of the Biodetox technology products and the results are then compared with the quality standard for wastewater set up by the Department of Health of Republic Indonesia (Permenkes RI No. 416/MENKES/PER/IX/1990), the quality standard for irrigation water (D Classification) of Department of Environment of Republic Indonesia (Kepmen KLH No.02/MENKLH/I/1988) and quality standard for fertilizer materials (Hammer, 2001). The Biodetox technology is expected to be used as the safe method to refine the hospital wastewater and to use the products as materials for fertilizer.

This research was conducted to study and analyze hospital wastewater using Biodetox biological technology and its potential to be a resource of materials for fertilizer; and to study the responses of Chinese cabbage (*Brassica juncea* L.) to the product.

MATERIALS AND METHODS

Experimental site and sampling

The studies on the water processing using the Biodetox technology and quality and characteristics of the RSUP Sanglah were conducted in the RSUP Sanglah. The survey and field observation on the RSUP Sanglah started from 15 May until 28 December 2009. Sample collection was carried out on 20 May 2009 and analysis of the wastewater were conducted in the faculty of Mathematics and Natural Resource Science laboratory of Gajah Mada University, Yogyakarta from 20 January to 20 April 2011. The study on plant responses was conducted in the glasshouse of Warmadewa University, Denpasar, Bali, Indonesia from 10 April until 15 June 2012.

Study on the operational process of Biodetox technology

There were four levels of processes but three important ones involved viz. pre-treatment (in A pond), treatment (in B pond) and stabilization (in C pond). The fourth level was disposition level (D pond) (Figure 1). The hospital wastewater with high BOD loads was drained to the equalization collection pond where physical (filtration, flocculation and coagulation) and chemical (chlorination) treatments were imposed to homogenize and to eliminate the pollutants. From this pond, the wastewater was then continually drained into A pond for the pre-treatment to be imposed. In this pond the separation of wastewater components (i.e. to simplify of the form and size of components) by microorganisms was occurred.

In the treatment level, the wastewater from the A pond drained into B one or aeration (open) pond, in which treatments of temperature, pH, oxygen, Food/Microorganism (F/M) were given to maintain the activities of microorganism to change organic into inorganic components through fermentation process, to eliminate the pollutants (such as H_2S, CH_4 and NH_3) and to decrease the amount of CO_2 and odor-related volatile organic compounds as well. Sludge was recirculated from the B into A pond to even more refine the wastewater.

In the stabilization level, the smaller components form of pollutant free-wastewater was drained from the B into C pond. In this stagnant pond, the wastewater components became more stable and gave the opportunity to the microorganisms (algae, fungi, protozoa and bacteria) degraded the components into even smaller forms to be available for plants.

Study on quality and characteristics of RSUP Sanglah wastewater

The quality (physical, chemical and biological) of the wastewater measured in pre-treatment, treatment, stabilization and disposition levels (in A,B,C and D ponds). The characteristics of RSUP Sanglah wastewater were analyzed from the stabilization level (in C pond).

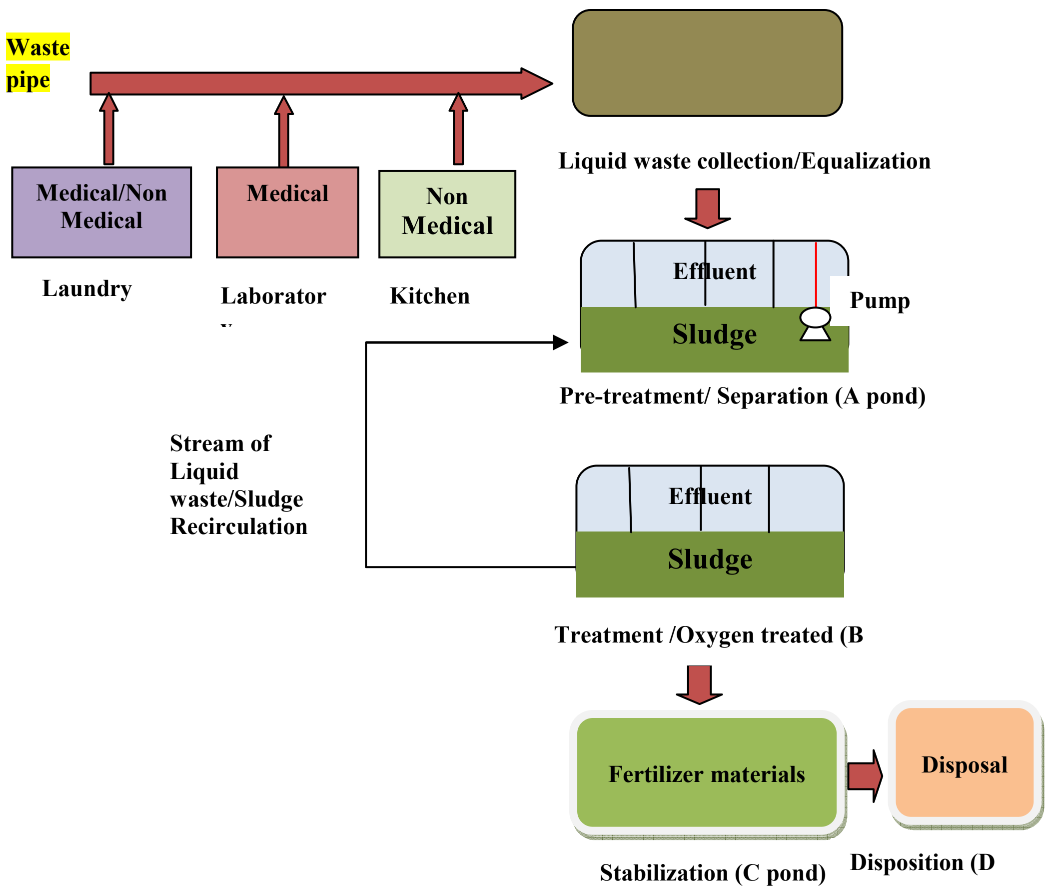

Fig. 1. The process of biodetox technology

Study on plant responses

A randomized complete block design was used to study responses of Chinese cabbage (*Brassica juncea* L.) in the glasshouse experiment. Three kinds of fertilizer (product of Biodetox technology on RSUP Sanglah wastewater, Biosugih commercial organic and Hyponex chemical fertilizers) and four rates of those fertilizers (0, 10, 20 and 30 g pot^{-1} of 20 cm diameter) were the treatments, which were factorially arranged. The experiment was conducted in a combination hydrophonic system, in which a seedling of Chinese cabbage was planted in a plastic bag of 20 cm diameter and 20 cm height filled with sterilized sand medium. Plants were given the fertilizers according to the treatments and watered with the same amounts of tap water once a day. The experiment was conducted for 110 days.

Data collection

Samples were taken from four points inside each of the four level of process (four ponds of hospital wastewater installation) to be analysed in the faculty of Mathematics and Natural Resource Science laboratory of Gajah Mada University, Yogyakarta to determine the quality, characteristic and number of nutrient components in the samples. Variables of leaf number, leaf area, leaf and total fresh weight plant^{-1} were measured in the glasshouse experiment. Leaf number was counted manually, leaf area plant^{-1} was calculated from the average of area (length x width) leaf^{-1} x leaf number plant^{-1}, whereas leaf and total fresh weight were obtained using an ordinary laboratory balance.

Physical and Chemical analysis

The physical (TSS and MLSS) characteristics of wastewater were analyzed with photometric method using TSS Portable Hand held Turbidity LXV322.9900002 system product (GLI International HACH radiometer analytic). Sulphide, magnesium, ammonia, ammonium acid, COD, BOD were analyzed titrimetrically using electrometric and digital titrator, catride 0.080 M, Test kit, 500 ml calcium magnesium indicator solution, 50 ml ammonia electrode filling solution, 5g/100 ml phenolphthalene indicator solution, TNT plus, BOD incubator.

The 8075 Total Kjeldahl Nitrogen, Nessler Range: 1-150 mg L^1, nitrogen ammonia standard solution, mg L^1, 500 ml NH_3-N was used to analyze N (Nitrogen organic). Nitrates and nitrites were analysed with spectrophotometric method using 8171 spectrophotometer Powder Pillows of AccuVac Range: 0.1-10.0 mg L^1 NO_3-N (HACH ACC Brand). P, K, Ca, Al, Fe and Mo were analyzed using Atomic absorption spectrophotometer (AA30, Varian, USA).

All metals, except calcium were atomized using acetylene and air. Calcium was atomized using nitrous oxide and air. Mn was analyzed using period oxidation method, range: 0.006-0.700 mg L^1 manganese reagent. Samples were digested using a mixture of nitric acid and hydrochloric acid.

High Performance Liquid Chromatography (HPLC) with UV detection (IC instrument, INC. USA) at 200 nm detection wavelength was used for the determination of target growth hormones (gibberellins, zeatin and IAA). Microorganisms and bacteria were calculated using 8091 MPN (Most Probably Number) method Coliform-Total and E-coli Lauryl Trypose w MUG Broth Most Probable Method. Range: MPN Count table, Dri-Bath 12-Well, 120 V (HACH, USA Brand) incubator. All analyses were conducted in the laboratory of the faculty of Mathematics and Natural Resource Science of Gajah Mada University, Yogyakarta (Gajah Mada University Laboratory, 2011).

The production of fertilizer was calculated using the equation (Kasmijo, 1991; Badan Penelitian dan Pengembangan Teknologi, 1996; Nugroho, 1996):

$$\frac{\text{the installation wastewater capacity } (m^3\ day^{-1})}{\text{the discharged wastewater } (m^3\ hr^{-1})} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

while the production of nutrients was determined from the nutrient microorganisms demand equation (Kasmijo, 1991; Badan Penelitian dan Pengembangan Teknologi, 1996; Nugroho, 1996) of :

$$BOD:N:P = 100:\%:1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Data of Chinese cabbage growth and yields from the glasshouse experiment were statistically analyzed using computer software of MSTATCand COSTAT

RESULTS AND DISCUSSION

The RSUP Sanglah discharged wastewater of 430 m^3 day^{-1} and only used 13.89% of the hospital installation plant capacity of 129 m^3 h^{-1}. Laboratory analysis indicated that the RSUP Sanglah wastewater was categorized as domestic wastewater dominated by organic matter such as proteins, carbohydrates and fats as indicated by parameters of TSS (Figure 2b), ammonia (Figure 3b), nitrates, nitrites (Figure 3c), Dissolved Oxygen Demand (DO) (Figure 4a), BOD and COD (Figure 4b).

The operational process of Biodetox technology

The Biodetox technology used in Sanglah General Hospital Center (RSUP Sanglah) had met the standard operational criteria for biological processing of wastewater. The steps of process of Biodetox technology showed that the technology had met the operational standard, due to focusing on biological principles with the concept of usage and quality of safe, efficient and environmental friendly wastewater. This was proved by the quality of wastewater produced in stabilization level or step (C pond) and in the disposition level (D pond) (Table 4.1) that already met the quality standard and safely used (Permenkes RI Nomor 416/MENKES/PER/IX/1990 and standar mutu air golongan D Kepmen KLH No -02/MENKLH/1/ 1988, Nugroho, 1996 and Hammer 2001). In addition, the characteristic of the wastewater produced in stabilization level also met the quality standard for fertilizer materials (Hammer, 2001).

The Quality of RSUP Sanglah wastewater

In the Biodetox technology with the BOD load of 577 g $m^3 \cdot day^{-1}$, the aeration period employed to the wastewater was 3.0 hour less than does in the operational standard (Table 1). Given F/M ratio of 0.20-0.50 g $BOD \cdot day \cdot g^{-1}$ MLSS and 35% sludge recirculation, the MLSS and TSS were far less than those in the the operational standard. The Biodetox technology resulted in the sludge age even shorter than in the operational standard and resulted in 88% BOD efficiency (Table 1).

Table 1. The measurements in biodetox-treated wastewater of RSUP Sanglah compared to operational standard of wastewater treatment

No.	Parameters	Units	Biodetox technology	Operational standard of wastewater treatment*)
1	Aeration period	hr day^{-1}	3.0	6-9
2	BOD load	g $m^3 \cdot day^{-1}$	577	500-800
3	F/M ratio	g/BOD/day/g MLSS	0.20-0.50	0.20-0.50
4	Sludge Recirculation	%	35	95
5	MLSS	%	17	25
6	TSS	%	78	82
7	BOD efficiency	%	88	85-95
8	Sludge age	day	2-4	5-10

* Hammer (2001)

Physical quality

This quality was indicated by a) temperature, b) turbidity, c) TSS, d) MLSS. The temperature increased from the lowest of 27.17 ^oC in pre-treatment level (A pond) to the highest of 28.9 ^oC in stabilization level (C pond). Those temperatures were in the range of allowed temperatures (26.00^{o}C-29.00^{o}C) according to the standard for Class D water quality (Kepmen KLH

No.02/MENKLH/I/1988) and were less than 30^oC (safe for fish and other microorganisms according to Peraturan Pemerintah Republik Indonesia No.82/2001). The increase in temperatures up to the stabilization level indicated the occurrence of biological process and changes in wastewater condition.

Turbidity value decreased from the highest of 818.30 NTU measured in the pre-treatment level (A pond) to the lowest of 185.68 NTU in the disposition (level D pond). (Figure 2a). TSS and MLSS values decreased as well from the highest 57.43 mg l^{-1} and 695.97 mg l^{-1} respectively measured in the pre-treatment to the lowest of 17.85 mg l^{-1} and 70.58 mg l^{-1} in the disposition level. (Figure 2b). The values are higher than the lowest value safe for water biology organism life (100 NTU) (Permenkes RI No.416/MENKES/PER/IX/1990).

The decreased in turbidity value explained that the separation between TSS, colloids, MLSS and effluent had occurred. The changes in physical quality due to solid degradation by microorganisms, also occurred as indicated by the decrease in TSS and MLSS.

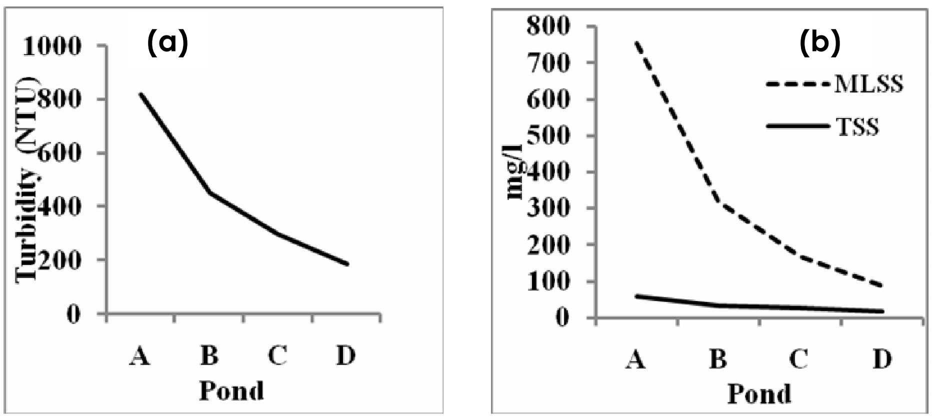

Fig. 2. The values of turbidity (a) TSS and MLSS (b) measured in the RSUP Sanglah wastewater

Chemical quality

The acidity (pH), nitrites (NO_2) and nitrates (NO_3), DO, BOD, COD, oil and detergents identified the chemical quality. The acidity was steady (pH of 7) from the pre-treatment until the stabilization but increased sharply to the disposition levels (Figure 3a), but on the other hand ammonia (NH3) decreased sharply from 86.81 mg l^{-1} in the pre-treatment to 0.06 mg l^{-1} in the disposition level (Figure 3b). The value of pH was in the range of 6-8.5 and considered safe for irrigation water (Standard for water quality according to Kepmen KLH No.2/MENKLH/I/1988).

Although nitrates were always lower than nitrites (Figure 3c), both components sharply increased from 1.62 mg l^{-1} and 0.19 mg l^{-1} respectively in the pre-treatment to 4.42 mg l^{-1} and 3.32 mg l^{-1} in the treatment levels but decreased afterward to the stabilization (4.00 mg l^{-1} and 0.20 mg l^{-1}) and finally increased slightly again (4.42 mg l^{-1} and 0.20 mg l^{-1}) to the disposition level.

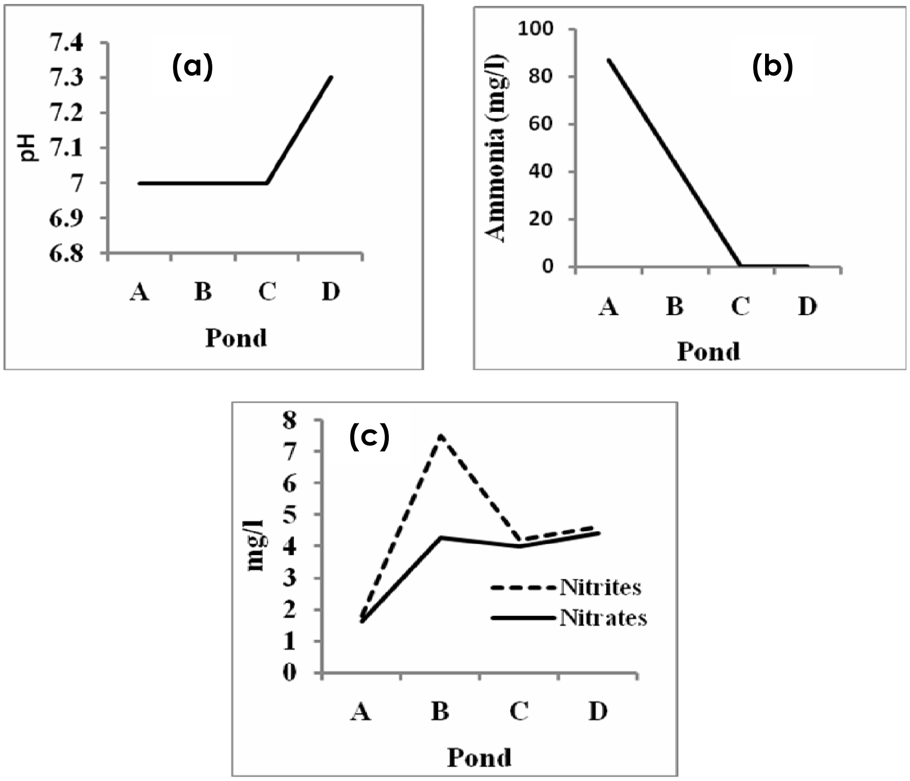

Fig. 3. The values of pH (a), ammonia (b), nitrites and nitrates (c) measured in the RSUP Sanglah wastewater

The DO, BOD and COD concentrations were also indicators of the existence of microorganisms and organic materials in the RSUP Sanglah wastewater. The DO concentration increased from 3.8 mg l^{-1} in the pre-treatment to 4.2 (in the treatment level) and 6.6 mg l^{-1} (in the stabilization level) and finally to 7.0 mg l^{-1} in the disposition level (Figure 4a). On the other hand the BOD and COD concentrations were continued to decrease from 80.43 and 168.0 mg l^{-1} respectively in the pre-treatment to 17.50 and 48.6 mg l^{-1} in the disposition level (Figure 4b).

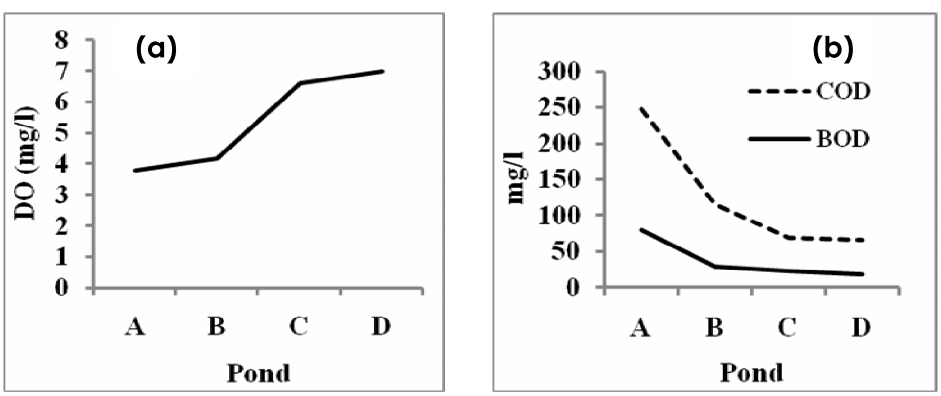

Fig. 4. DO (a), COD and BOD (b) measured in the RSUP Sanglah wastewater

Biological quality

The non-coliform biofilm slime detected in the wastewater, indicated the existence of coliform bacteria in the wastewater (Figure 5). The slime was assumed as the product of the coagulation resulting from the chlorination process.

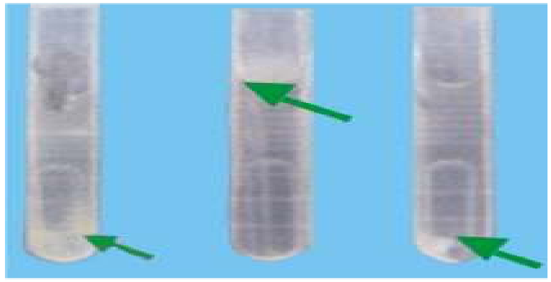

Fig. 5. The non-coliform biofilm slimes (pointed by arrows) detected in the Sanglah Hospital wastewater

The characteristics of RSUP Sanglah wastewater

The characteristics of RSUP Sanglah wastewater analyzed from the stabilization pond are indicated by the parameters presented in Table 2. The BOD was 2.63 mg l^{-1} higher but COD was 3 mg l^{-1} lower than in the quality standard for fertilizer materials. Although the ammonia was far less, phosphates were extremely higher than it is supposed to be in the standard. There were no heavy metals measured in the RSUP Sanglah wastewater. On the other hand, the total bacteria found was 24.0 MPN 100 ml^{-1} wastewater. The product of Biodetox technology on RSUP Sanglah wastewater resulted in water quality that met the standard criteria for irrigation water and for fertilizer materials.

Table 2. The characteristics of the RSUP Sanglah wastewater analyzed from the stabilization level and the quality standard for fertilizer materials

No.	Parameters	Units	Measurement results	The quality standard for fertilizer materials*
1	Temperature	^oC	28.90	30
2	pH	-	7.0	6.0-9.0
3	TSS	mg l^{-1}	25.83	5-50
4	BOD	mg l^{-1}	22.63	10-20
5	COD	mg l^{-1}	47	50-100
6	Ammonia	mg l^{-1}	0.17	42.11
7	Phosphates	mg l^{-1}	74.82	0.1-30
8	Heavy metals) (Hg, Cd, Ni	-	0	Hg<0.001; Cd<0.01; Ni<0.02-0.1
9	Total Bacteria	MPN 100 ml^{-1}	24.00	10,000 colony 100 ml^{-1}

* Hammer (2001)

Nutrient Content of the Biodetox Treated-Hospital Wastewater

Laboratory analysis indicated that the RSUP Sanglah wastewater potentially contained 1.97% N, 0.78% P, 0,43% K, 0,48% Ca, 0.33% S, 0.19% Mg, 326 ppm Fe, 211 ppm Al, 18.8 ppm Mn, 2.18 ppm Mo. After processing with the Biodetox technology the content of metals measured in the stabilization pond were 0.96 mg l^{-1} Fe, 0.08 mg l^{-1} Al, 0.11 mg l^{-1} Mn, 0.19 mg l^{-1} Mg and 0.22 mg l^{-1} Mo. Additionally, total amino acids, hormones (gibberellins, zeatin, IAA) and microorganisms (coliform and fecal coli) were also found in the product (Gajah Mada University Laboratory, 2011).

Production of Fertilizer Materials and Nutrients

Based on the calculation (Eq. 1) it was found that the TSS in the effluent (as the material for fertilizer) was 8.6 kg day^{-1}, which was originated from 430 m^3 day^{-1} hospital discharges collected in a 129 m^3 hr^{-1} aeration pond with 500 mg MLSS l^{-1} influent, 100 mg TSS l^{-1} influent, 173 mg BOD l^{-1} and 37,41 mg MLSS l^{-1} (Table 1). From nutrient microorganisms demand equation value of BOD:N:P = 100:%:1 (Eq.2) (Kasmijo, 1991;Badan Penelitian and Pengembangan Teknologi, 1996; Nugroho, 1996), it was calculated that Biodetox products could provide 5.250 kg N day^{-1} and 1.05 kg P day^{-1}.

Plant Responses to the Biodetox Treated-Hospital Wastewater

Results of statistical analysis showed that the effects of interaction between types and rates of fertilizer were highly significant on leaf and total fresh weight $plant^{-1}$. The single effect of types or rates of fertilizer were highly significant on all growth and yield variables measured.

The effects of interaction between types and rates of fertilizer on leaf and total fresh weight plant^{-1}

The effect of interaction between type and rates of fertilizer showed that the product of Biodetox at the rate of 15 g pot^{-1} resulted in 19.90% and 17.35% higher leaf fresh weights (FW) $plant^{-1}$ of Chinese cabbage than that of Biosugih and Hyponex, respectively (Table 3). That rate of Biodetox product gave 56.86% higher leaf FW compared to control, while that of Biosugih and Hyponex only gave 47% and 37.13%, respectively. The Biodetox product rate of 20 g pot^{-1} resulted in lower leaf FW than the rate of 15 g pot^{-1} but significantly higher than the rate of 10 and 0 g pot^{-1}. The Biosugih rate of 20 g pot^{-1} did not give significantly different leaf FW from the other rates, while that rate of Hyponex gave significantly lower leaf FW than the other rates (Table 3).

Table 3. The effect of interaction between type and rate of fertilizer on leaf and total fresh weight $plant^{-1}$

	Type of fertilizer		
Rates (g pot^{-1})	**Biodetox**	**Biosugih**	**Hyponex**
	Leaf fresh weight $plant^{-1}$		
0	4.40 de	4.33 de	5.30 d
10	4.87 de	3.50 ef	4.17 de
15	10.20 a	8.17 b	8.43 b
20	6.73 c	4.67 de	2.57 f
	Total fresh weight $plant^{-1}$		
0	4.40 de	4.33 de	5.30 d
10	4.87 de	3.50 ef	4.17 de
15	10.20 a	8.17 b	8.43 b
20	6.73 c	4.67 de	2.57 f

Notes: Means in a row or column at each parameter followed by a common letter are not significantly different at 5% Duncan's Multiple Range Test.

The Biodetox product rate of 15 g pot^{-1} resulted in the highest total FW of 14.13 g plant^{-1}, which was 26.19% and 16.28% higher than that of Biosugih and Hyponex and was also higher than those of the other treatments (Table 4). The rate of 20 g pot^{-1} of Biodetox product increased the total FW plant^{-1}, while that of Biosugih did not give any significant difference but on the other hand that of Hyponex decreased the parameter compared to control.

The single effect of types and rates of fertilizer on maximum leaf number and leaf area plant^{-1}

The highest leaf number and leaf area at all measurements were given by Biodetox which were significantly higher than tose of the other two fertilizers (Table 4). The effect of rate of 15 g pot^{-1} on the leaf number but on the leaf area the effect, which just shown at 20 and 30 dap, were not significantly different from those of 10 g pot^{-1}. These data also indicated that based on the types of fertilizer, the product of Biodetox technology was safe and even gave the highest leaf number and leaf area pot^{-1}.

Table 4. The single effect of type and rate of fertilizer on leaf number and leaf area plant^{-1}

Treatment	Leaf number	Leaf area plant^{-1} at		
		10 DAP	20 DAP	30 DAP
	(leaves)	……………………(cm^2)………………		
Types of fertilizer				
Biodetox (K)	10.33 a	2.096 a	5.18 a	5.06 a
Biosugih (B)	8.25 b	0.814 b	2.53 b	2.56 b
Hyponex (V)	8.33 b	0.987 b	3.05 b	2.54 b
5% LSD	1.015	0,316	1,354	1,033
Rates of fertilizer (g pot^{-1})				
0 (K0)	7.22 b	1.30 b	2.01 b	2.73 b
10 (K1)	8.44 b	1.02 b	3.56 a	3.56 ab
15 (K2)	9.67 a	1.30 b	5.00 a	4.65 a
20 (k3)	7.55 b	1.18 b	3.78 a	2.61 b
5% LSD	1,172	0,365	1,564	1,192

Note: Means in a column followed by a common letter are not significantly different at 5% LSD

It was statistically proven that at the rate lower than 15 g pot^{-1}, there was no significant difference in leaf and total FW among all types of fertilizers. These indicated that the products of Biodetox technology could be used as fertilizer as safe as Biosugih commercial organic and chemical Hyponex fertilizers and even resulted in higher total FW at the rate of 15 g pot^{-1}.

The fact that the product of Biodetox technology was apparently safe for Chinese cabbage were associated with its quality and characteristics that were not only met with the quality standard of water irrigation (Kepmen KLH No.2/MENKLH/I/1988) but also met with the quality standard of fertilizer materials (Hammer, 2001). The physical, chemical and biological qualities and the nutrient content of the product (measured in the stabilization level of process) that consisted of 1.97% N, 0.78% P, 0.43% K, 0.48% Ca, 0.33% S, 0.19% Mg, 326 ppm Fe, 211 ppm Al, 18.8 ppm Mn, 2.18 ppm Mo (Gajah Mada University Laboratory, 2011), may be associated with plant growth requirements. Additionally, amino acids, hormones and microorganisms that were also found in the product might contribute to the plant growth. There were no heavy metals (such as Hg, Cd and Ni) found in the product (Table 2) indicating the safety of the product for human and environment (WHO, 1989; FAO,1992).

Results of this research also indicated that the Biodetox technology on RSUP Sanglah wastewater of 430 m3 day^{-1} has the potential to produce fertilizer materials (in the form of sludge) of 8.6 kg day^{-1} (Eq.1) with the production of N:P in the ratio of 5.250 kg day^{-1} : 1.05 kg day^{-1} (Eq.2).

CONCLUSION

The Biodetox technology used in Sanglah General Hospital Center (RSUP Sanglah) met the standard operational criteria for biological processing of wastewater. The product of Biodetox technology on RSUP Sanglah wastewater resulted in levels that met the standard criteria for irrigation water quality and for fertilizer materials.

The product of Biodetox technology of RSUP Sanglah wastewater was categorized as safe as Biosugih brand commercial organic and Hyponex chemical fertilizers to Chinese cabbage. Its use resulted in 41.7% higher total fresh weight of the crop compared to the other two fertilizers.

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