BIOREMEDIATION OF EFFLUENT WASTEWATER TREATMENT PLANT BOJONGSOANG BANDUNG INDONESIA USING CONSORSIUM AQUATIC PLANTS AND ANIMALS

Wibowo Mangunwardoyo[1,*], Tony Sudjarwo[2] & Mufti Petala Patria[1]
[1]Department of Biology, Faculty of Mathemathic and Natural Sciences, University of Indonesia, Depok, 16424. Indonesia.
[2]Doctoral Degree Student, Department of Biology, Faculty of Mathemathic and Natural Sciences, University of Indonesia, Depok, 16424. Indonesia.
*Author for Coresspondence : 62-21-7270163 Fax: 62-21-78884762
w_mangunwardoyo@yahoo.com or wibowo.mangun@ui.ac.id

ABSTRACT
Volume of domestic or household waste increased by 5 millions meter cubic per year, with an increase in the average content of up to 50%. Components in the domestic waste water can lead to imbalances disrupt aquatic ecosystems and human health, such as the presence of *Escherichia coli*, and the possible presence of hazardous substances such as elemental N, P, As, Cr, and Se which can lead to poisoning of fish, birds and mammals. Bioremediation is the application of biotechnology domestic wastewater utilizing living things include plants and animals as agents of degrading pollutants. This research uses a consortium of *Eichhornia crassipes* (F1), *Salvinia molesta* (F2), *Ceratophyllum demersum* (F3), as well as aquatic animals *Anodonta woodiana* (Z1) and *Limnodrilus hoffmeisteri* (Z2) because it has a high potential to degrade or absorbing compounds in domestic wastewater. Experiments using Randomized Complete Design (RCD), 12 treatments and 3 replicates. Observed levels of efficiency (Ef) and the rate of degradation (Ld) or rate of gradation (Lg). Observations of turbidity, color and froth domestic wastewater done for 14 days. Testing or measurement of physical and chemical properties at day-0, the 1st, 3rd and 5th. The results revealed a consortium F1F2F3Z1Z2 on turbidity Ef 86%─Ld 14 mg/L/day, BOD Ef 70%─Ld 19 mg/L/day, COD Ef 67%─Ld 31 mg/L/day and clear the fastest on day 4; consortium F2F3Z2 on ammonia Ef 95%─Ld 0.62 mg/L/day, nitric Ef 91%─Ld 0.11 mg/L/day and the lowest gradation TDSEf 0%─Ld 0 mg/L/day, F1F2F3Z1 consortium gradation lowest TSS Ef 50%─Lg 1 mg/L/day, and a consortium F1F3Z1 Ef 77%─Ld 1.30 mg/L/day in nitrate.

Keywords: *Bioremediation, domestic wastewater, aquatic plants, aquatic animals.*

I. INTRODUCTION

The amount and activity of the population is increasing every year. Along with this increase also waste that is produced and released into the environment, either in the form of solid waste, liquid or gas. The volume of domestic waste increased by 5 million meter cubic per year, with an increase in the average content of 50% [1] If allowed to continue to enter the environment directly will cause environmental problems, because the processing rate is lower than the natural rate of output and input. Components in the domestic wastewater can lead to an imbalance of aquatic ecosystems and human health, such as pathogenic microorganisms (e.g.*Escherichia coli*) and nutrients namely Nitrogen (N) [2,3,4] and the possible presence of hazardous substances or elements, the presence of N, P, As, Cr, and Se can cause toxicity[2].

Domestic wastewater by bioremediation is the use of environmentally friendly biotechnology organisms (natural treatment system) to degrade or absorp of pollutants that endanger human health [4] and other organisms. The ability of these organisms are absorbed (absorption), outlines, save (deposit) and cell metabolism. It is expected that the pollutants in the domestic wastewater can be reduced or lost by plants and aquatic animals. Domestic wastewater effluent discharged into public water bodies or agricultural utilization as raw water and fresh water fish breeding is not expected to contain a hazardous substance [4] or more below the dangerous threshold (Minister of Environment of the Republic of Indonesia Number: 112/2003, Domestic Wastewater Quality Standard: TSS 100 mg/L, BOD 100 mg/L and pH 6–9).

Bioremediation studies using aquatic plants *Eichhornia crassipes* in domestic wastewater treatment showed 81% reduction in Chemical Oxygen Demand (COD), 91% Biochemical Oxygen Demand (BOD), 16% of Total Dissolved Solids (TDS), 70% of Total Suspended Solids (TSS), 4% Chloride (Cl), 74% ammonium-nitrogen (NH2-N), 41% Phosphate (PO4-P), 96% of Most Probable Number (MPN) and 98% TVC (total viable count); *Salvinia molesta* can

remediate metal heavy Cd and Cr contained in the liquid waste [5] and *Ceratophyllum demersum* remediate toxic metals [6]. Bioremediation studies using aquatic animals, namely *Anodonta woodiana* (gravestone taiwan) and *Limnodrilus hoffmeisteri* (worm water) showed capable of absorbing harmful elements [7]. The ability of plants and aquatic animals is the reason their use to degrade or absorb pollutants domestic wastewater.

Wastewater treatment process is influenced by environmental factors, namely physical factors include humidity, temperature, rainfall, light, turbidity and sediment; chemical factors include degree of acidity (pH), the content of inorganic and organic elements, BOD, COD and content of nitrate compounds and phosphate; biological factors include the biomass of aquatic organisms and coliforms [8]. Management control of the factors that affect domestic wastewater is supporting increased efficiency of the wastewater treatment process [2].

Wastewater Treatment Plant (WWTP) Bojongsoang, Bandung, is one of the domestic wastewater. Managed by the Regional Water Company (PDAM) Bandung. Domestic wastewater entering the WWTP Bojongsoang is toilet wastewater (black water) derived from households, restaurants, hospitals (non-pharmaceutical waste), hotels, schools and offices were channeled through the piping system since 1992 covering the area of Bandung Central, East and South. Design Bojongsoang major WWTP consists of physics processing includes equipment for separating garbage and sand, biological processing include the processing ponds in series consisting of anaerob, facultative and maturation ponds. The design is generally the main aim to reduce BOD and COD in addition to reducing or eliminating pollutants in domestic wastewater. USAID survey in 2006 (the footage is not a year unknown performance Bojongsoang the WWTP effluent COD was decreased content of 57.5%, reduction in BOD content of 56.75%, and coliform 1.6×10^2 MPN/100 mL.

2. MATERIAL AND METHODS

2.1. Plants and Animal

Aquatic plants used in this study is *E. crassipes*, *S. molesta* and *C. demersum* obtained from the surrounding environment and Bojongsoang Cibiru Bandung. The animals of water used is *A. woodiana* obtained from Cangkuang Garut district and *L. hoffmeistri* obtained from Waste Water Treatment Plant Bojongsoang environment.

2.2 Research Design

Research conducted in test basins size 40 cm × 80 cm × 50 cm by 15 pieces, consisting of bath supplies acclimatization and 3 pieces, and hair treatments as much as 12 pieces given aeration. Test basins are located in the green house Research Center of Natural Resources and Environment (PPSDAL) Unpad Bandung. Domestic wastewater tested each treatment as much as 50 liters. Combination treatment consortium can be seen in Table 1. Experiments designed Randomized Complete Design (RCD) with 12 treatments and 3 replicates..

Table 1. The combination of water plants consortium *E. crassipes*, *S. molesta* and *C. demersum*, as well as aquatic animals *A. woodiana* and *L. hoffmeistri* on bioremediation of domestic wastewater from the WWTP Bojongsoang

No.	Treatment	*E. crassipes* (F1)	*S. molesta* (F2)	*C. demersum* (F3)	*A.woodiana* (Z1)	*L. hoffmeistri* (Z2)
1.	Control	×	×	×	×	×
2.	F1F2F3	● (6)	● (6)	● (6)	×	×
3.	F1F2Z1	● (6)	● (6)	×	● (2)	×
4.	F1F3Z1	● (6)	×	● (6)	● (2)	×
5.	F2F3Z1	×	● (6)	● (6)	● (2)	×
6.	F1F2F3Z1	● (6)	● (6)	● (6)	● (2)	×
7.	Z1Z2	×	×	×	● (2)	● (±1000)
8.	F1F2Z2	● (6)	● (6)	×	×	● (±1000)
9.	F1F3Z2	● (6)	×	● (6)	×	● (±1000)
10.	F2F3Z2	×	● (6)	● (6)	×	● (±1000)
11.	F1F2F3Z2	● (6)	● (6)	● (6)	×	● (±1000)
12.	F1F2F3Z1Z2	● (6)	● (6)	● (6)	● (2)	● (±1000)

Notes:
● = use in the treatment;
× = not use in the treatment;
(2), (6) and (±1000) = number of individuals

2.3. Parameter assays

Parameters measured/tested among other physical parameters include turbidity, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia (NH_3-N), nitrite (NO_2-N), nitrate (NO_3-N) and phosphate (PO_4-N). Measuring or testing of physical and chemical parameters was carried out on day 0, the 1st, 3rd and 5th in the Environment Quality Control Laboratory (LPKL) Bandung. Reference method and main test is opted from [9]. Calculated efficiency and rate of degradation, as well as minimum residence time is determined to show the great value of degradation.

2.4. Observations

Observations were made every day for turbidity, color and froth on domestic wastewater testing. Observations of turbidity, color and froth done scoring. Scoring uses the numbers 1 through 5. Scoring is based on the level of turbidity, color and froth of water that can be observed in domestic wastewater test (Table 2). Degradation time is also determined by observing the minimum score of 1 on a "day to how" for turbidity and water color.

Table 2. Scoring observations turbidity, color and froth on domestic wastewater bioremediation experiments

Aspects of waste water were observed	Criteria scoring				
	1	**2**	**3**	**4**	**5**
Turbidity	Clear	Slightly turbid	Turbid medium	Turbid many	Very cloudly
Color	Clear	A little green	Being green	Many green	Very green
Froth	Not frothy	A little frothy	Frothy medium	Frothy many	Very frothy

Environmental factors including temperature measured daily water use alcohol thermometers, water pH using a pH-meter, temperature and humidity using wet and dry hygrometers.

3. RESULT AND DISCUSSION

3.1. Preliminary studies area and instalation

Bojongsoang WWTP located 12 km South of Bandung, located 675 m above sea level in the district of Bandung regency Bojongsoang, wide 85 ha, from 7.00 to 7.28° latitude coordinates and 107°14' to 107°16'East Longitude. Managed by PDAM Bandung under Wastewater Director. Domestic wastewater is treated graywater, it was the waste waterthat comes from human feces and urine, as well as the rest of the laundry kitchen and bathroom. The wastewater flows through an integrated pipeline system that covers about 60% of the city area towards the WWTP Bojongsoang Bandung.Bojongsoang WWTP consisting of physical and biological treatment plant. Physical treatment plant consists of equipment which aims to filter or separate wastewater from waste large and small, as well as pushing it towards stabilization ponds. The equipment includes manual bar screen, screw pump, mechanical screw pump, mechanical bar screen, grit chamber and grit rake. Biological treatment plant consists of three stabilization ponds that have a primary goal to reduce BOD and COD. These include a ponds as much as 3 arranged parallel anaerob, facultative composed by 2 by 2 parallel and maturation in series. The composition of the pool consists of 2 sets of the set A and set B. Stabilization ponds totaled 14. Treated wastewater at the WWTP Bojongsoang much as 28.542,2 m^3 per year (2011).

3.2.Preliminary studies on the quality of domestic wastewater WWTP Bojongsoang

The results preliminary studies of domestic wastewater quality from November 2011 to February 2012 can be seen in Table 3. The quality of domestic wastewater in the WWTP Bojongsoang, still shows a value above the quality standard for turbidity, TSS, BOD, COD, ammonia, nitrite and phosphate. It refers to domestic wastewater quality standards according to Minister of Environment No. 112/2003 (*) and the Indonesian Government Regulation No. 82/2001 (**) Group III of the raw water to freshwater aquaculture, livestock and agriculture.

The result is a portrait that WWTP Bojongsoang capacity in 2012 decreased compared since the beginning of operations in 1992. Natural treatment processes in stabilization ponds primarily aims to reduce BOD and COD, as well as other parameters [10]. The cause is silting stabilization pond, blooming algae and human activities such as stabilization ponds trout fishing, duck grazing and collection of worm water. It disrupts the natural processes that take place on the domestic waste water utilizing sunlight exposure, microbial activity and other aquatic organisms, especially those that have roles as decomposers are bacteria, fungi and worms water.

Tabel 3. Preliminary studies on the quality of domestic wastewater WWTP Bojongsoang from November 2011 to February 2012.

Parameter	Unit	Quality standard	Result of measured/test		
			Anaerob	Facultative	Maturation
Physics					
Turbidity	NTU	25**	41,4	440,6	86,70
Total Dissolved Solids (TDS)	mg/L	1000**	255,7	216,55	121,40
Total Suspended Solids (TSS)	mg/L	100*	56,00	91,34	190,05
Chemistry					
N-Ammonia (NH_3-N)	mg/L	0,5**	2,35	1,94	2,08
N-Nitrat (NO_3-N)	mg/L	20**	10,09	10,23	8,45
N-Nitrit (NO_2-N)	mg/L	0,06**	0,18	0,88	0,34
Phosphate (PO_4)	mg/L	1**	3,44	1,36	2,50
Arsen (As)	mg/L	1**	<0,0005	<0,0005	<0,0005
Selenium (Se)	mg/L	0,05**	<0,01	<0,01	<0,01
BOD_5	mg/L	100*	381,50	113,00	381,00
COD	mg/L	50**	389,65	198,15	547,71
The degree of acidity		6–9*	6,95	7,90	8,70
Biology					
Coliform	Total/100 mL	2.000**	55.230	55.550	968

3.3. Preliminary studies of environment factors and benthos in WWTP Bojongsoang

At the end of January 2012 is to study environmental factors and benthos in ponds WWTP Bojongsoang processing. The results of a preliminary study of environmental factors can be seen in Table 4. The results of the analysis of benthos studies during the week at the Research Center for Natural Resources and Environment (PPSDAL) can be seen in Table 5. Calculation of diversity index (ID) the Shannon-Wiener on benthos abundance indicates a value of less than 1. This value indicates that the domestic wastewater "heavily polluted" category. Individuals were dominated by the *Chironomus* and *Tubifex*.

Environmental factors including temperature, pH, intensity and brightness indicates the value of the optimal life span of aquatic organisms. But every pond benthos diversity index indicates otherwise. Diversity index (ID) with anaerobic, facultative and maturation respectively 0.14, 0.41, 0.56. Overall average value is 0.34. These values describe the diversity or abundance of benthos is low (less than 1). The situation is influenced by the physical and chemical characteristics of the waste water in the pond anaerobic, facultative and maturation [11,12].

The low value of ID benthos likely influenced by the content of ammonia, nitrite, nitrate and phosphate. Ammonia, nitrite, nitrate and phosphate were high so it can be deadly toxic organisms, including benthos. It is also supported by the discovery of some benthos in surface or sewage treatment pond edges. The emergence of benthos on the surface to be an important indicator that the probability of the benthos escape to the content of ammonia, nitrite, nitrate and phosphate to be deadly. Therefore, the content of ammonia, nitrite, nitrate, and phosphate rate may be a limiting factor of benthos in the pond processing of WWTP Bojongsoang. Thus the assessment of the quality of domestic wastewater in the WWTP Bojongsoang can also be done from the diversity index of benthos [13].

.

Table 4. Environmental factors measured in treatment ponds WWTP Bojongsoang.

No.	Point sample	Depth (m)	DO (mg/L)	Temperature (°C)	pH	The intensity of light (lux)	Brightness (m)
1	A1.1	4.0	1.1	26.2	7.1	398	15
2	A1.2	4.0	1.1	26.8	7.2	400	15
3	A1.3	4.0	1.1	27.0	7.1	395	17
4	A2.1	4.0	3.9	26.8	7.1	250	12
5	A2.2	4.0	1.7	26.4	7.0	250	14
6	A2.3	4.0	3.0	27.2	7.0	360	17
7	A3.1	4.0	1.6	26.6	7.0	250	10
8	A3.2	4.0	2.6	26.8	7.1	250	10
9	A3.3	4.0	3.8	26.8	6.8	349	16
Average		**4.0**	**2.2**	**26.7**	**7.0**	**322.4**	**14.0**
10	F1.1	2.5	3.1	26.0	7.1	350	15
11	F1.2	2.5	5.4	26.3	8.3	208	15
12	F1.3	2.5	9.5	27.4	9.8	395	15
13	F2.1	2.5	3.6	26.4	7.1	349	15
14	F2.2	2.5	6.2	28.3	8.8	402	9
15	F2.3	2.5	11.7	28.1	9.4	308	15
Average		**2.5**	**6.6**	**27.1**	**8.4**	**335.3**	**14.0**
16	M1.1	1.5	8.1	27.2	9.0	310	6
17	M1.2	1.5	8.1	26.6	8.2	308	6
18	M1.3	1.5	2.4	25.8	8.8	200	5
19	M2.1	1.5	4.5	26.2	9.3	200	8
20	M2.2	1.5	10.6	27.7	10.2	72	5
21	M2.3	1.5	11.2	27.8	10.4	60	5
Average		**1.5**	**7.5**	**26.9**	**9.3**	**191.7**	**5.8**
Total average		**2,8**	**5.4**	**26.9**	**8.3**	**283.1**	**11.3**

Notes:
A1=Anaerob pond 1, A2=Anaerob pond 2, A3=Anaerob pond 3;F1=Facultative pond 1, F2= Facultative pond 2;
M1=Maturation pond 1, M2= Maturation pond 2;1= Inlet, 2=Midlet, 3=Outlet

Table 5. Preliminary studies on the benthos in biological treatment pond WWTP Bojongsoang

Organism	Stations																				
	Anaerob 1			Anaerob 2			Anaerob 3			Facultative 1			Facultative 2			Maturation 1			Maturation 2		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Tubifex	0	0	0	0	0	0	0	0	0	1652	84	1890	6510	546	2282	336	910	322	322	2884	420
Chironomus	0	0	0	0	0	14	0	0	0	2610	18648	7224	1918	1344	6020	1652	7224	9646	2338	3500	31276
Lumbriculus	0	0	0	0	0	0	0	0	0	0	14	0	14	0	0	14	0	0	56	0	14
Lymnaea	0	0	0	0	0	28	28	0	0	0	0	0	14	0	0	0	42	98	0	14	70
Melanoides	0	0	0	28	0	0	0	0	0	0	0	0	0	0	0	0	0		0	28	
Belastoma	0	0	0	0	0	0	0	0	0	294	0	0	0	126	0	0	0	14	0	0	14
Macromya	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	14	0	0	0	0	14
Tarebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Gyroulus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Helobdella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0
Fomacea	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number	**0**	**0**	**0**	**42**	**0**	**42**	**28**	**0**	**0**	**4556**	**18746**	**9114**	**8456**	**2030**	**8302**	**2030**	**8176**	**10108**	**2716**	**6426**	**31808**
Index of Diversity (ID)	**0,00**	**0,00**	**0,00**	**0,64**	**0,00**	**0,64**	**0,00**	**0,00**	**0,00**	**0,86**	**0,03**	**0,51**	**0,56**	**0,83**	**0,59**	**0,57**	**0,38**	**0,23**	**0,46**	**0,73**	**0,10**
Average ID		**0,00**			**0,42**			**0,00**			**0,47**			**0,66**			**0,39**			**0,43**	
					0,14							**0,56**						**0,41**			
Total average ID												**0,34**									

3.4. Bioremediation observations

Observations quality, minimum time turbidity and water color results bioremediation of domestic wastewater effluent from the WWTP Bojongsoang using consortium *E. crassipes*, *S. molesta* and *C. demersum*, as well as aquatic animals *A. woodiana* and *L. hoffmeistri* can be seen in Table 6. Temperature and pH of the wastewater as well as temperature and humidity indicates the optimum value aquatic organisms living in all treatments.The lowest

scoring color and turbidity of 1.9 by 2.0 occurred in F1F2F3Z1Z2 treatment (Table 6 and Figure 1). It shows that in this research consortium F1F2F3Z1Z2 for lowering the turbidity and color of domestic wastewater. F1F2F3Z1Z2 consortium also showed better lowering turbidity and color compared with domestic wastewater treatment F1F2F3 (water plants only) of 2.8 and treatment Z1Z2 (aquatic animals only) of 3.6. Ability F1F2F3 and Z1Z2 to absorb pollutants and domestic wastewater is increased when combined. Presumably in the consortium F1F2F3Z1Z2 there are mutually supportive interaction in the absorption or degradation of pollutants in domestic wastewater. Such interactions are aquatic plants provide aerobic environment for aquatic animals, aquatic animals while providing compounds in the water to be more apart or into forms available to aquatic plants. Formed a little froth on treatment F1F2Z1, F1F3Z2, F2F3Z2 and F1F2F3Z2. Possible Z1 and Z2 the treatments resulted in the excretion of the formed bubbles when reacting with air (from the aerator).

Wastewater turbidity and color is determined by the presence of particles dissolved in it. Activity of organisms and microorganisms can reduce the presence of such particles. Aquatic plants (F1, F2, F3) and aquatic animals (Z1, Z2) tested in this study has the ability to perform the extraction, degradation and stabilization of the particles. While microbes (bacteria and fungi) particle decomposition ability. Consortium F1F2F3Z1Z2 can enhance and accelerate the clean up of particles dissolved in the domestic wastewater [14].

Table 6. Observations quality, minimum time turbidity and water color results of bioremediation the domestic wastewater uses of aquatic plants and animals in WWTP Bojongsoang

No.	Treatment	Wastewater					Minimum time		Environment factor	
		Temperature (°C)	**pH** (1–14)	**Turbidity** (1–5)	**Color** (1–5)	**Froth** (1–5)	**Turbidity** (hari)	**Color** (hari)	**Temperature** (°C)	**Humidity** (%)
1.	Kontrol	22,3	8,9	3,9	3,8	0,0	12,0	14,0	24,7	76,1
2.	F1F2F3	22,2	8,4	2,3	2,8	0,0	8,0	11,7	24,7	76,1
3.	F1F2Z1	22,2	8,2	2,1	2,3	0,4	5,7	9,0	24,7	76,1
4.	F1F3Z1	22,3	8,3	2,0	2,2	0,0	5,7	8,7	24,7	76,1
5.	F2F3Z1	22,3	8,7	2,4	2,6	0,0	6,0	10,7	24,7	76,1
6.	F1F2F3Z1	22,2	8,4	2,0	2,1	0,0	6,7	9,0	24,7	76,1
7.	Z1Z2	22,3	8,8	3,4	3,6	0,0	12,0	14,0	24,7	76,1
8.	F1F2Z2	22,3	8,3	2,4	2,8	0,0	7,7	10,0	24,7	76,1
9.	F1F3Z2	22,4	8,4	2,3	2,3	0,1	7,7	5,3	24,7	76,1
10.	F2F3Z2	22,4	8,7	2,6	2,8	0,2	10,0	14,0	24,7	76,1
11.	F1F2F3Z2	22,2	8,2	2,2	2,2	0,9	7,3	8,3	24,7	76,1
12.	F1F2F3Z1Z2	22,3	8,1	1,9	2,0	0,0	4,0	6,7	24,7	76,1

Notes:
F1: *E. crassipes*; F2: *S. molesta*; F3: *C. demersum*; Z1: *A. woodiana*; Z2: *L. hoffmeistri*.

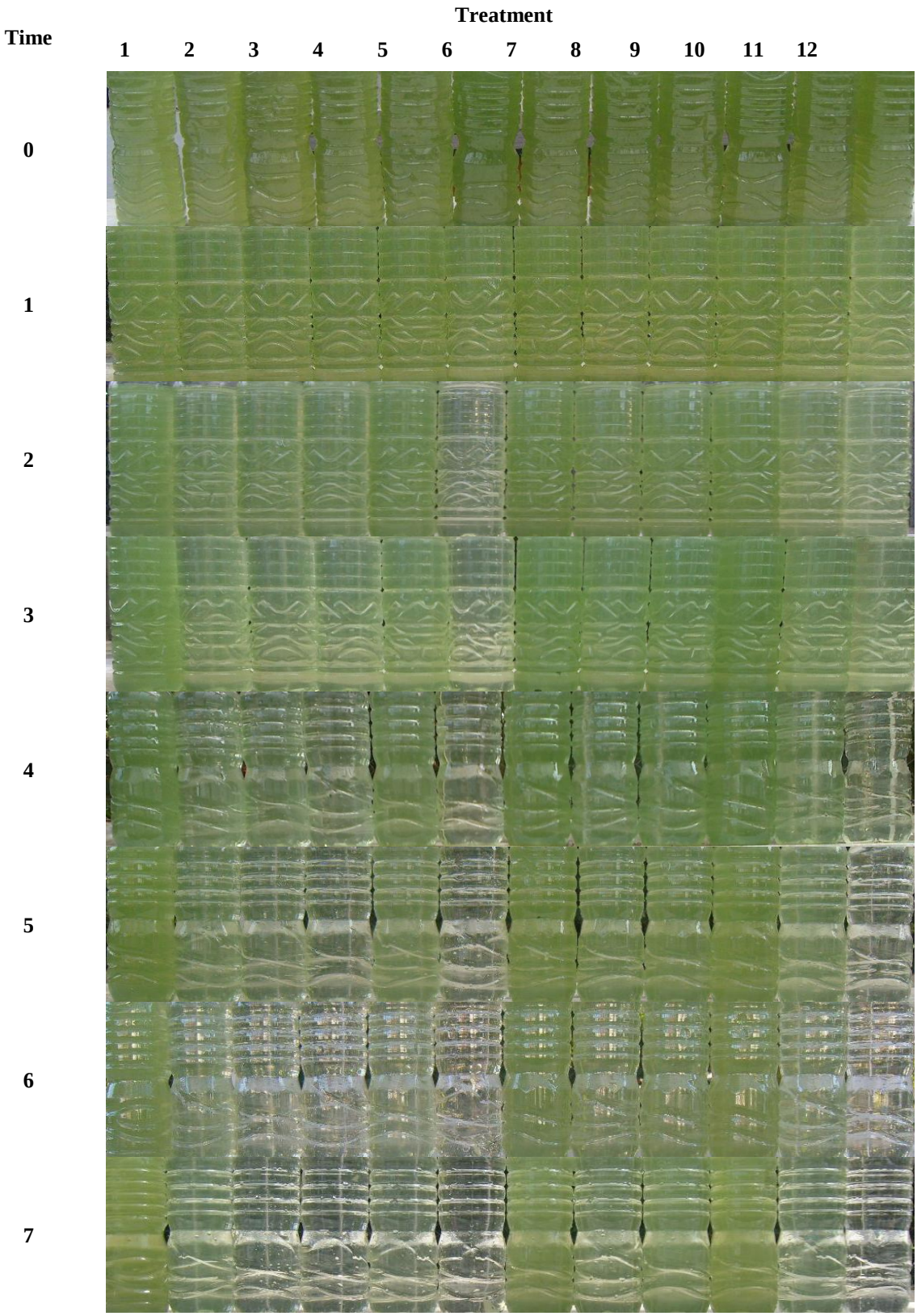

Figure 1. Observations domestic wastewater bioremediation using consortium aquatic plants *E. crassipes*, *S. molesta* and *C. demersum*, as well as aquatic animals *A. woodiana* and *L. hoffmeistri* on day 0 up to day 7. Treatment sequence from left to right are the controls, F1F2F3, F1F2Z1, F1F3Z1, F2F3Z1, F1F2F3Z1, Z1Z2, F1F2Z2, F1F3Z2, F2F3Z2, F1F2F3Z2 dan F1F2F3Z1Z2

.Table 7. Efficiency and degradation rate of bioremediation of domestic wastewater effluent the WWTP Bojongsoang using consortium *E. crassipes*, *S. molesta* and *C. demersum*, and aquatic animals *A. woodiana* and *L. hoffmeistri*

No.	Treatment	Turbidity		TDS		TSS		BOD		COD		Amonnia		Nitrite		Nitrate		Phosphate	
		Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld	Ef	Ld
1	Controle	-330	-54	-3	-1	-538	-14	-46,25	-12	-8	-4	86	0.56	80	0.10	39	0.65	-41	-0.02
2	F1F2F3	80	13	-5	-2	-350	-9	21,25	6	27	13	77	0.50	69	0.09	60	1.02	-191	-0.11
3	F1F2Z1	60	10	-11	-4	-137	-4	47,50	13	48	22	82	0.53	80	0.10	73	1.23	-75	-0.04
4	F1F3Z1	76	12	-10	-4	-212	-6	51,25	14	54	25	83	0.54	80	0.10	**77**	**1.30**	-115	-0.07
5	F2F3Z1	-65	-11	-2	-1	-425	-11	21,25	6	24	11	87	0.57	77	0.10	61	1.02	-73	-0.04
6	F1F2F3Z1	61	10	-7	-3	**-50**	**-1**	32,50	9	36	16	72	0.47	71	0.09	76	1.28	-36	-0.02
7	Z1Z2	-82	-13	-2	-1	-275	-7	-5,00	-1	-2	-1	67	0.44	45	0.06	29	0.49	-76	-0.04
8	F1F2Z2	-13	-2	-8	-3	-200	-5	25,00	7	24	11	63	0.41	78	0.10	58	0.97	-98	-0.06
9	F1F3Z2	-20	-3	-9	-4	-275	-7	32,50	9	28	13	91	0.59	57	0.07	48	0.81	-73	-0.04
10	F2F3Z2	-101	-17	**0**	**0**	-425	-11	-27,50	-7	-21	-10	**95**	**0.62**	**91**	**0.11**	36	0.60	-46	-0.03
11	F1F2F3Z2	6	1	-8	-3	-88	-2	43,75	12	46	21	91	0.59	77	0.10	18	0.30	**-20**	**-0.01**
12	F1F2F3Z1Z2	**86**	**14**	-11	-4	-88	-2	**70,00**	**19**	**67**	**31**	90	0.59	85	0.11	20	0.33	-96	-0.05

Notes:
F1: *E. crassipes*; F2: *S. molesta*; F3: *C. demersum*; Z1: *A. woodiana*; Z2: *L. hoffmeistri*; Ef: Eficiency (%); Ld: Degradation rate (mg/L/day).
Sign of negative (-) show gradation (enhancement); Gradationrate (Lg).

Treatment F1F2F3Z1Z2 indicates the minimum time is the fastest in reducing turbidity, which is 4.0 days. While the decline in water color is the second fastest after F1F3Z2 6.7 days, which is 5.3 days. Consortium F1F2F3Z1Z2 has the ability to absorb or degrade pollutants higher than other treatments. Consortium F1F2F3Z1Z2 composed by aquatic plants are F1, F2 and F3 with aquatic animals are Z1 and Z2. Plant which has roots with broader and can remediate pollutants through absorption, adsorption, transport and translocation, hyperaccumulation or transformation and mineralisation [15, 16]. Z1 or decomposer role as decomposers of organic material, and Z2 which has a capacity of 10 liters of water filtration per day.

Analysis of physical and chemical properties of domestic wastewater bioremediation results consortium of aquatic plants and animals with reference to the method of APHA shows three phenomena, namely the overall degradation, partial degradation and gradation. Overall degradation occurs in ammonia, nitrite and nitrate. Partial degradation occurs in turbidity, BOD and COD. Gradation occurs in TDS, TSS and phosphate.

Ammonia is a form that is not ionized at pH greater than 7 (Table 6). The efficiency and the highest degradation rate of ammonia occurred in the last 4 treatments F1F3Z2 (Ef 91%, Ld 0.59 mg/ L/day), F2F3Z2 (Ef 95%, Ld 0.62 mg/L/day), F1F2F3Z2 (Ef 91 %, Ld 0.59 mg/L/day) and F1F2F3Z1Z2 (Ef 90%, Ld 0.59 mg/L/day). All four are better than the water treatment plants and animals only. Nitrite is a form of compounding results overhaul nitrifying bacteria from ammonia. Its toxic, water was within a short time. The efficiency and the highest rate of degradation occurred in the treatment F2F3Z2 Ld Ef 91% and 0.62 mg/L/day. Nitrate is the ultimate form of ammonia by bacteria nirifikasi overhaul of nitrite. Treatment F1F3Z1 showed the highest efficiency at 77%, with the degradation rate of 1.30 mg/L/day. Treatment F1F2F3Z1Z2 demonstrate the efficiency and the highest degradation rate of turbidity (Ef 86%, Ld 14 mg/L/day), BOD (Ef 70%, Ld 19 mg/L/day), and COD (67%, Ld 31 mg/L/day). The results of this research indicate that the consortium *E. crassipes* (F1), *S. molesta* (F2), *C. demersum* (F3), *A. woodiana* (Z1) and *L. hoffmeistri* (Z2) is to reduce turbidity, BOD, COD, ammonia, nitrite and nitrate in the water.

Gradient TDS and TSS occurred in all treatments. This shows that the consortium F1F2F3Z1Z2 increase dissolved and suspended solids. Treatment F2F3Z2 demonstrate the efficiency grading lowest TDS is 0%. The treatment does not increase the dissolved solids in the water compared to the other treatments. While grading TSS by treatment F1F2F3Z1 shows the efficiency (50%) and the rate of gradation (1 mg/L/day) lows. Dissolved and suspended solids this research can increase turbidity and sediment.

All agents involvement role in degrading pollutants domestic wastewater can be seen in Table 8 and highest treatment in Figure 2. The order of largest to the smallest role in the consortium is *S. molesta* (F2), *C. demersum*

(F3), *E. crassipes* (F1), *L. hoffmeistri* (Z2) and *A. woodiana* (Z1). Role indicates the interaction of all agents in the consortium according to certain parameters of each function in the ecosystem.

The ability of aquatic plants (F1, F2 and F3) in this research include phytoextraction (phytoaccumulation), phytostabilisation, phytovolatilisation, phytodegradation, and rhizofiltration [15, 17]. Phytoextraction (phytoaccumulation) are absorption through the roots so that the water and the elements or compounds that are dissolved in it into the vascular tissue and then the elements or compounds that are considered dangerous are stored in the vacuole of cells. Phytostabilisation done bioavailability plants by reducing pollutants in the environment and hold it around the roots so it does not spread. Plants phytovolatilisation done by evaporation or evapotranspiration through the leaves, so the leaves are wide and have a large stomata will have a high ability. Phytodegradation done through the interaction of plants with microorganisms around their roots, include bacteria, yeast and fungi. Phytodegradation can take place because the plants provide an aerobic environment for the microorganisms and the microorganisms have the ability to remodel so that the organic material into inorganic results more easily absorbed by plants. Rhizofiltration is using of plant roots to absorb or adsorb pollutants from water. According [18] phytoremediation mechanisms of organic contaminants use two mechanism, (1) direct uptake of contaminants and subsequent accumulation of nonphytotoxic metabolites into the plant tissue, and (2) release of exudates and enzymes that stimulate microbial activity and the resulting enhancement of microbial transformations in the rhizosphere (the root zone).

Table 8. Involvement of the role of *E. crassipes* (F1), *S. molesta* (F2), *C. demersum* (F3), *A. woodiana* (Z1) and *L. hoffmeistri* (Z2) degrade pollutants in domestic wastewater.

No.	Parameter	*E. crassipes* (F1)	*S. molesta* (F2)	*C. demersum* (F3)	*A.woodiana* (Z1)	*L. hoffmeistri* (Z2)
Analysis of observations of physical properties						
1	Turbidity	●	●	●	●	●
2	Color	●	●	●	●	●
Analysis of physical and chemical properties in the laboratory						
1	Turbidity	●	●	●	●	●
2	TDS		●	●		●
3	TSS	●	●	●	●	
4	BOD	●	●	●	●	
5	COD	●	●	●	●	●
6	Ammonia		●	●		●
7	Nitrite		●	●		●
8	Nitrate	●	●		●	
9	Phosphate	●	●	●		●

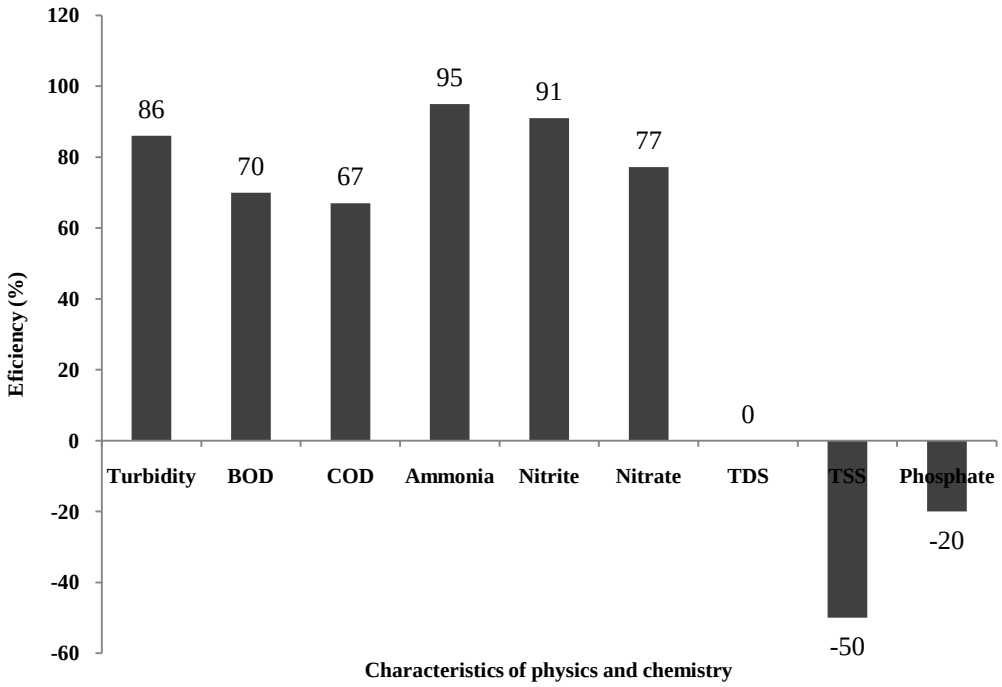

Figure 2. Eficiency the highest degradation of characteristic physics and chemistry by consorsium *E. crassipes* (F1), *S. molesta* (F2), *C. demersum* (F3), , *L. hoffmeistri* (Z2) and *A. woodiana* (Z1)to domestic wastewater WWTP Bojongsoang.

Anadonta woodiana filtering water and absorbing elements or compounds in it by mouth, gills, and then empties into the chiffon. Some accumulate in the body's cells and partly excreted. *Limnodrilus hoffmeistri* remodel organic pollutants by releasing enzymes. Aquatic animals, like plants, can do zooextraction, zoostabilisation and zoodegradation [7].

This study shows that the consortium *E. crassipes*, *S. molesta*, *C. demersum*, *A.woodiana* and *L. hoffmeistri* both in decreased turbidity, BOD, COD, ammonia, nitrite and nitrate. But the consortium is not so good in decreasing TDS, TSS and phosphate. The increase in dissolved solids, suspended solids and phosphate excretion to do with *A. woodiana* and *L. hoffmesitri*. Both are metabolic waste excretion and digestion that contains volatile organic compounds clumping and forming phosphate experimental environment. It can be observed with the formation of sediment at the bottom, though slightly. Problems efficiency of consortiums in TDS, TSS and phosphate can be enhanced through the addition of microorganisms that perform better.

4. CONCLUSIONS

Consorsium of aquatic plants *E. crassipes*, *S. molesta*, *C. demersum* with aquatic animals.*A. woodiana* dan *L. hoffmeisteri* have high potential to degradation of turbidity, BOD, COD, ammonia, nitrite and nitrate domestic wastewater. However, it less to degrade of TDS, TSS and phosphate.

5. ACKNOWLEDGEMENT

The research was supported by Directory of Research and Public Service, University of Indonesia under Grant Research Madya University of Indonesia (RM-UI) in the years 2012, Dra. Betty Wediawati as in Head of WWTP Bojongsoang for kindly helps and Sunardi, Ph.D. a Head of Research Center for Natural Resources and Environment Unpad Bandung, and Environment Quality Control Laboratory permitting to analyse the physical and chemical characterization.

6. REFERENCES

[1] K. Haryoto, Kebijakan dan strategi pengolahan limbah dalam menghadapi tantangan global. Di dalam: Teknologi Pengolahan limbah dan pemulihan kerusakan lingkungan. *Prosiding Seminar Nasional*, Jakarta 13 Juli 1999, BPPT, Jakarta. (1999).

[2] G. Bitton *Wastewater microbiology. 3rd ed*. A John Wiley & Sons, Inc., Publication, Florida. (2005).

[3] K. A. Cameron, The efficiency and mechanisms for pollutant removal in biological wastewatertreatment systems. Thesis. *Department of Agricultural and Biosystems Engineering, McGill University* (2001).

[4] N.F. Gray, *Biology of wastewater treatment. 2nd ed*. Imperial College Press, London.(2001).

[5] Sudibyaningsih. Aquatic weed *Eichhornia crassipes* and *Salvinia molesta* as phytoremidiator metals cadmium and hexavalent chromium in wastewater treatment. *Agris. Record*. (University General Sudirman, Navan (Indonesia), Faculty of Biology (2001).

[6] U.N. Rai, S. Sinha, R.D. Tripathi, P. Chandra. Wastewater treatability potensial of some aquaticmacrophyte: Removal of heavy metals. *Ecology Enginering* **5**:5-12 (1995).

[7] S. Gifford, R.H. Dunstan, W. O'Connor, C.E. Koller and G.R. MacFarlane. Aquatic zooremediation:deploying animals to remediate contaminated aquatic environments. *Trends in Biotechnology* **25** (2): 60-65 (2006).

[8] R.H. Kadlec, R.L. Knight. *Treatment Wetlands*. CRC Press Inc..(1996).

[9] American Public Health Association (APHA). *Standard methods for the examination of water & wastewater*. *21st edition*. APHA AWWA WEF, Washington (2005)

[10] D. Mara, *Domestic wastewater treatment in developing countries*. Earthscan, London (2003).

[11] K.A. Habeeba, P. Saltanat, and A. Uzma. A study seasonal variations of benthic community and biodiversity indices in relation to environmental variables in disturbed ponds. *International Journal of Environmental Science*, **2**(4): 2120–2125 (2010).

[12] J.A. Fynn, I. Galyuon, D.W. Aheto, I. Okyere. Assessment of the environmental condition and benthic macroinvertebrate communities in two coastal lagoons in Ghana. *Annals of Biological Research*, **2**(5): 413–424. (2011).

[13] P. Koperski, Diversity of freshwater macrobenthos and its use in biological assessment: a critical review of current applications. *Environment Review NRC Research Press*, **19**: 16–31 (2011).

[14] S. Dhote, S. Dixit. Water quality improvement through macrophytes: A case study. *Asian Journal Experimental Science*, **21** (2): 427–430 (2007).

[15] R.R.Hinchman, M. C. Negri, E.G. Gatliff. *Phytoremediation: using green plants to clean upcontaminated soil, groundwater, and wastewater*. Argonne National Laboratory and Applied Natural Sciences, Inc. (1998).

[16] R.B. Meagher,. Phytoremediation of toxic elemental and organic pollutants. *Current Opinion in Plant Biology*, **3**: 153–162. (2000).

[17] J. P. Schwitzguébel, *Potential of phytoremediation, an emerging green technology*. Laboratory for Environmental Biotechnology (LBE), Swiss Federal Institute of Technology, Lausanne.International Conference of Ecosystem Service and Sustainable Watershed Management in North China, Beijing.(2000).

[18] J.L. Schnoor, L. A.Licht, S. C.McCutcheon, N. L. Wolfe, L.H. Carreira. Phytoremediation of organic and nutrient contaminants, *Environ. Sci. Technol.*, **29** (7). (1995).