Research Paper Medical

A study of Sewage Treatment System by Pandanus Amaryllifolius in Man-Made Wetland

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ABSTRACT

Many environmental experts say wetlands are the "kidneys" to nature. Wetland is a type green technology, which only uses natural plants without using any sophisticated equipment or toxic chemical. It is a screening technology and natural treatment that works clean and treat contaminated water or sewage.. The main focuses in this research are to evaluate the quality of the treated water after the treatment process using man-made wetland system and to review the effectiveness of the man-made wetlands in refinery process wastewater. When Pandanus Amaryllifolius growth in the man-made wetland site and can be seen the rate of growth is increasing, it indicates that the plant has earned a good nutrient levels of induction of waste water through the plant. This can be associated with a high rate of absorption of nutrients from the wastewater. Pandanus Amaryllifolius (pandanus) used as a tool in the screening process wastewater naturally. A series of experiments were conducted to examine the effectiveness of this man-made wetlands, among them is the chemical oxygen demand (COD), pH, turbidity samples, color samples, searching compounds in Pandanus with GCMS, and the last one is looking for the total concentration of chlorine, chlorine, nitrate, sulfate and phosphate to predict water quality after a man-made wetlands. From the data obtained, the COD value was reduced from 70 mg/L to 39.25 mg/L. As well as the nitrate and phosphate, both concentration of the substance are reduced to a safe level of 1.10 mg/L and 19.42mg/L. These findings prove the man-made wetland systems have shown that the water quality can be increased to the certain level that is safe to be released into the environment.

INTRODUCTION

Sewage is one type of wastewater that derived from the residential area, such as apartments, commercial centers, industrial and agricultural processes [2]. Raw sewage is the main content of urine and feces from toilets and other forms of human waste types. However, these substances are not sewage from residential areas but the creator of the raw material. It can also be caused by industrial site drainage, discharge from sewage treatment plants, water washing, and the flow of rain water from the roof [4].

Man-made wetland technology is a system that is designed, planned and constructed with wetland plants to aid in the treatment of sewage in a controlled environment compared to natural wetlands. The main purpose of building a Man-made wetland is removing suspended solids, nitrogen, phosphorus, organic matter, pathogenic and nutrients such as ammonia. Many developing countries have been actively developing the technology Man-made wetlands, since they have realized that the system offers advantages over natural trickling filtration system. Wetlands would typically be built on high ground and out of the flood plain or flood water flow' it is intended to prevent damage to wetlands and other natural resources such as aquatic life, plants drains, etc. Wetlands are often constructed by digging, backfilling, grading, diking and installing water control structures to create hydraulic flow patterns required. If the site has a very permeable soil, tight, compacted clay liner is usually installed and placed on top of the original soil liner [4]. Wetland vegetation will be planted accordingly or allowed to grow naturally, but most of the wetland plants will be selected after making the study of the nature of his ability already in the process of sewage filtration.

Several rules must be followed in constructing wetlands. These regulations have been proposed by the United States Environmental Protection Agency (EPA). First, the construction of the wetland should Consider the role of treatment wetlands within the watershed (example Potential water quality impacts, surrounding land Uses and relation to local wildlife corridors The first thing that should be emphasized in the construction of man-made wetlands is its role in water catchment areas (eg wildlife habitats, the potential impacts to water quality, etc.). besides further study such as the presence of endangered species, Hydrology, critical habitats, and factors that can prevent unintended consequences.[5]. The most important in the construction of the wetland is using effective water control system, which is able to respond easily in water quality changes, the quantity (in water levels). Wetland monitoring and maintenance should also be done on a regular basis and have a long-term management plan [6].

Wetlands will improve water quality; therefore, wetland is a unique system and valuable to human, because it affects water flow and water quality. Wetlands will improve water quality by intercepting surface runoff and removing or retaining inorganic Nutrients, processing organic wastes, sediments and suspended Reducing reach open water for hire before [10]. Problems such as increased quantities of algae, fish kills due to excessive quantities of nutrients and also the dead zone can be resolved through this wetland system. However, if the flow of water entering the wetland is carrying too much sediment, pollutants and nutrients it can lower the ability of wetlands, thus a drainage system and self-regulation effective level required [9].

There are 3 types of wetlands are often constructed in treat-

ing wastewater, Surface flow (SF), subsurface flow (SSF), and floating aquatic plant (FAP) system [14]. For this research, it uses subsurface flow (SSF). SSF constructed wetland bed of gravel, soil media, and the rock where it is sewage flowed. Beds were placed at ground level, and the waste water enters the bed at about mid-depth. Type of crops grown on the surface of the SSF wetland is hydrophytes plants, often in a shallow layer of pine straw, wood chips, or other mulch. Roots of these plants extend into the saturated bed. Bottom slope, medium porosity and the average daily flow is critical engineering factors that must be considered in order to maintain proper hydraulic gradient wastewater as it passes through the bed. These factors must be at serious note, because this causes a failure in open pit flow levels increase and cause damage to the wetland [11].

Currently, the researchers are studied about several type of plant that can be more efficient as nature filter system in the man-made wetland. There are thousands of species of plants of wetland, but not all plants suitable for planting in the process of treatment. In Malaysia still lack information about the plants that are suitable for carrying out the treatment process in the wetland. Therefore this study will use the pandanus plant wetland plants. Actually, phosphorus and nitrogen in the sewage will be uptake by plants as a nutrient for nitrogen it changes into gas and released to the atmosphere, it will be a source of nutrients to the plants, when the bacteria in the soil will act to change the main nutrient nitrogen on plants [7]. For the Phosphorus, it has no change on gas but it will be modified by vascular plants found in the wetland. These plants will alter phosphorus from organic forms of phosphorus into organic forms in their biomass as they grow. So the evident of those wetlands help to remove nitrogen and phosphorus from the water through certain conditions [8].

The main objective of this research are to evaluate the quality of the treated water after the treatment process using man-made wetland system and to review the effectiveness of the man-made wetlands in refinery process wastewater.

METHODOLOGY

A. Materials

In this research, it has used pandanus amaryllifolius and several chemical such as DPD Total Chlorine powder pillow, DPD Free Chlorine powder pillow, SulfaVer 4 Reagent powder pillow, NitraVer 5 Reagent powder pillow, PhosphaVer 5 reagent powder pillow, distilled water, COD Digestion Vial Reagent, Ethanol and chloroform to measure the quality of water after pas through the wetland system.

B. Construction of wetland

A wetland site was cleaned up in advance of the other plants which it grows wild in the wetland site. Each channel connector from the holding tank to the floating wetlands, and also to man-made wetlands was cleared. It seeks to ensure that the channels are not blocked or contain solid materials that can interfere with the flow. Subsequently, the sewage flow attempt was carried out in advance to ensure there is no disruption in the flow, and the flow of sewage in laminar flow. Next, pandanus was planted in the tank of man-made wetlands. Planting method and plant spacing depends on the size of the wetland used. For this study, distance used is 5 cm from each tree was in accord with the size of the man-made wetland. Sewage flows (90 ml/s) are directly applied to new plants cultivated [15].

C. Determination of pandanus size

This study was designed to identify the relationship of growths rates pandanus and the effectiveness of the screening process in man-made wetlands. The length and width of pandanus leaves, height of pandanus and pandanus canopy was measured by using measuring tape. Where A1 = width of leaf, A2 = length leaves, B = length of pandanus, C = Width of pandanus canopy. All the measurement data were taken every week for two months

D. COD Test

2.5ml water samples sewage were taken and put into a tube that contain COD Digestion Vial Reagent, at the same time 2.5 mL of distilled water was taken and inserted in the tube that contain COD Digestion Vial Reagent and become as a blank. Both of tubes then were put into a COD digester at a temperature of 150ºC for 2 hours. By using the spectrophotometer, the concentration of both solutions was read and recorded. [12]

E. Turbidity Test

The turbidity meter was switch on 30 min before experiment start. The 4000NTU solution was prepay by 5 mL of hydrazine sulphate solution was mixed with 5 mL Hexamethylenetetramine in standard 100 ml measuring flask. Mixture was left for 24 hours. After 24 hours the volume of the mixture was increased to 100 ml with distilled water turbidity free. 4000NTU solution is already available. Turbidity meters were calibrates to 400NTU using the standard calibration solution by adjusting the knob. Then one again turbidity meter was calibrated to 0 NTU using the distilled water and by adjusting the calibration knob. Sample was later placed into the meter and turbidity readings were recorded [13]

F. Concentration of Chemical Compound in Sewage Test

To study the concentrations of chemicals such as, total chlorine, free chlorine, sulfate, nitrate and phosphate in sewage. A simple experiment was conducted. 10 ml of sewage sample was inserted into each of 5 different bottles. Each bottle was added with a different reagent that is DPD Total Chlorine powder pillow, DPD Free Chlorine powder pillow, SulfaVer 4 Reagent powder pillow, NitraVer 5 Reagent powder pillow, PhosphaVer 5 reagent powder pillow. After 5 minutes, using a spectrophotometer the concentration readings was recorded. [17]

G. GCMS Test

Gas chromatography–mass spectrometry (GCMS) was used to search for content in pandanus leaves in wetland systems and also grown in normal soil. Ethanol and aqueous solution chlorophom used to extract the contents in pandanus leaves. Then the sample was labeled with pandanus leaves from the wetland system + ethanol (E1),pandanus leaves from regular land + ethanol (E2), pandanus leaves from the wetland system + chlorophom (C1), pandanus leaves from regular land + chloroph (C2).All samples were put into a GCMS system. Sample was injected into the GCMS at a temperature of 120. Then the sample was run in the system for an hour at a temperature of 200C. By using STDs as a carrier gas, the sample was run in RTX-5 column.

RESULT AND DISCUSSION

A. Concentration of Chemical Compound in Sewage

i. Free chlorine and total chlorine

Based on experimental data in Table 1 obtained from the concentration of total chlorine and free chlorine in sewage samples, it is observed that the concentration of total chlorine decreases when pass filtering wetland system, it is from 0.09mg/L to 0.05 mg/L. it varies with the concentration of free chlorine. The concentration of Free chlorine also decrease when pass through the wetland system, it is from 0.244 mg/L to 0.04 mg/L. Fact from WHO, the total chlorine is a combination of free chlorine and some other elements such as ammonia or organic nitrogen compounds [20]. If the concentration of ammonia decreases will result in total chlorine concentration will decrease. Reliable the ammonia and organic nitrogen compounds have been absorbed by the soil or plants that be planted on wetlands for used as nutrients.

ii. Concentration of Sulfate, Nitrate, and Phosphate

In determining the quality of water, experiments on concentration of sulfate, nitrate, and phosphate were performed. Data from the experiments (table 1) has shows sulfate concentrations decreased after going through this wetland system. It from 43.5 mg/L to 4.0 mg/ L, while data for Nitrate and phosphate concentrations were decreased after going through nat-

ural filtration system. The nitrate concentration from 6.9 mg/L to 1.1 mg/L and phosphate were from 36.3 mg/L to 11.43 mg/L.

From some of the facts, the concentration of sulfate, can increase are caused by several factors, is due to the increase of sulfate found in the soil or because it has no specific system for treating sulfate. According to a study that was reviewed by Choi-hai and his group, it says sulfate can only be treated or reduced through the process of reverse osmosis (RO), Distillation, Ion Exchanger and anaerobic digestion process [18]. If the sulfate concentration is too high, it can cause the water to become bitter and can have laxative effects. The world health organization (WHO) has determined that the allowable concentration is 250-500 mg/L [20], before it is discharged into water sources.

Nitrate (NO_3) is one form of nitrogen found in many different forms in aquatic ecosystems. Nitrate is the most important nutrient in the plant. But it must be in the correct concentration, as if the very high concentrations can cause a dramatic increase in aquatic plants and changes in vegetation. This in turn causes a lack of dissolved oxygen content of the water [21]. Based on the data obtained, the concentration produced by the wetland system is still at a low rate of 1.1 mg/L. According to the world health organization authorized nitrate concentration is below the 10 mg/L. [20].

Sewage is a major source of phosphorus. As we know, phosphorus is an essential nutrient for plants that make up the aquatic food web. It is the same as nitrate, if the concentration of phosphorus is too high can result in accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals. Concentration recommended by the world health Organization (WHO) is between 30 mg/L and below [22], [23]. Compare the data obtained, the concentration phosphorus out of the system is safe 11.43 mg/L

iii. Color, Turbidity and pH Test

Turbidity and color of the water is the first analysis must be determine to show whether the water is suitable as a source of drinking or released into the main source of water collection. Through the data obtained (table 1) it show turbidity and color of the water at low. It, turbidity and color in 8.12 NTU and 256 PtCO. The rate of color and turbidity of the water will affect the rate of diffusion of sunlight into the water. If it is too high it will affect their diffusion rates and slow down the process of photosynthesis, at the same time the plants will die and reduce dissolved oxygen and increase of carbonic acid in the water. If the turbidity and color rate is too high it also can stimulate the growth of bacteria [20]. Along with E. coli, pH, and chlorine residual, turbidity is one of the key parameters of microbial water quality [20]. It is also used to measure the effectiveness of water filtration. If water is to be chlorinated, it should have a turbidity of ≤5.0 NTU. Chlorination is even more effective at less than 1.0 NTU [24]. Chlorination will still be relatively effective up to 20 NTU, but this should only be done until measures can be taken to reduce the turbidity [25].

The pH value from the data that has been released it shows a sample water comes out of the wetland system is equivalent to a neutral pH (pH 6:59). pH is a very important factor because it is closely related to biological productivity. Traditionally, a pH between 6.5 and 8.5 is to show good water quality [26].

iv. COD Test

Chemical Oxygen Demand (COD) is the total measurement of all chemicals in the water that can be oxidized. COD is using to measures all organic carbon with the exception of certain aromatics (benzene, toluene, phenol, etc.) which are not completely oxidized in the reaction. COD concentration from table 1 shows a decline from a high of 70 mg/L before entering the wetland system to 39.25 mg/L after passing this natural filtration system. According to the world health organization (WHO) the quality of the water should not have a COD value of less than 8.0 mg/L compared to the results obtained with COD values set by the WHO, the water sample is not suitable as a main water source to human. But for this research it only developed a simple wetland system. For the future studies may need to be added some other tools that can reduce the COD to acceptable levels [28].

Table - 1
Characteristic of sewage data

Characteristic	Raw Sewage	Without Pandanus	With Pandanus
Total chlorine (Cl_2) mg/L	0.09	0.07	0.05
Free chlorine (Cl_2) mg/L	0.24	0.12	0.04
Sulfate [SO^{-2}_4] mg/L	43.50	12.00	4.00
Nitrate [NO^{-}_3] mg/L	6.90	2.10	1.10
Phosphate [PO^{3-}_4] mg/L	36.30	19.42	11.43
Color (PtCO)	352	295	256
Turbidity NTU	31.30	9.03	8.12
pH	6.20	6.30	6.59
COD mg/L	74.00	70.00	39.25

B. Growth Rate of Pandanus

Based on the fact that state growth rate is dependent on the concentration of nutrients found in sewage, the higher the concentration of nutrients in the sewage, it will increase the rate of plant growth manmade wetlands. Pandanus growth rate is influenced by the nutrients taken from sewage through wetlands. Evidenced by the data collected in table 2, each week, Pandanus increased growth. Logically, if Pandanus managed to absorb; some material from wastewater, this means filtering process occurs naturally. This also shows that the Pandanus is suitable as refinery plants in wetland systems.

Table - 1
Grow rate of Pandanus in the wetland system

Time (d) W		Leave (cm) L		Plant canopy (cm)	Plant Hight (cm)	No. of new leave
7	Plant 1	2.2	23.4	44	19	2
	Plant 2	2.4	20.5	42	26	3
	Plant 3	1.8	19.5	35	17	2
	On soil	2.2	22.9	43	20	2
14	Plant 1	2.2	25	47.5	20	2
	Plant 2	2.4	25.5	43.0	27	1
	Plant 3	1.9	22	39	18	1
	On soil	2.2	23.5	45	20	2
21	Plant 1	2.4	25.5	51	20	2
	Plant 2	2.6	26	45	31	3
	Plant 3	2.0	23	39.5	19	3
	On soil	2.2	23.8	48	20	2

CONCLUSIONS

Man-made wetland system is a system that can help in the management of the sewage system. This system does not require high construction cost and sophisticated technology. Using natural resources as the key equipment in the filtration system, man-made wetlands can provide good quality water to be released into the scene. A survey of planting Pandanus amaryllifolius on man-made wetland systems have shown that the water quality can be increased to a level that is safe to be released into the environment. In addition, plants grown in artificial wetlands system can also be used to generate additional income. These findings prove the plants are safe and have no toxic elements harmful to the consumer. Might in future research, some things can upgraded in the research such as use of different plants and at the same time a more systematic tools such as use the bacteria in the system immobilization for wastewater treatment.

REFERENCES

[1] Pratik A. Patel and Nishith A. Dharaiya (2013), Manmade Wetland For Wastewater Treatment With Special Emphasis On Design Criteria , Department of Life Sciences, University, PATAN. | [2] Kenneth D., Simeral, (2012) Using constructed wetland for removing contaminants from livestock wastewater, Ohio State University Fact Sheet, School of Natural Resources. | [3] Victor W.E. Payne, Donald L. Stettler, Dr. Robert L. Knight, Barry Kintzer, David C. Moffitt, (2002), Chapter 3 Constructed Wetlands, United States Department of Agriculture | [4] Kadlec, R.H., and R.L. Knight (1996). Treatment wetlands. Lewis Pub., Boca Raton, FL. | [5] EPA, (1999) Constructed Treatment Wetlands, United State Environmental Protection Agency | [6] Nancy Ross, Pacific Institute, (2010), WORLD WATER QUALITY FACTS AND STATISTICS, Pacific Institute | [7] Reddy, K.R., and T.A. DeBusk. (1987), State-of-the-art utilization of aquatic plants in water pollution control. Water Science and Technology, Vol. 19, (61-79). | [8] Katherine B. (1999), Health Risks of Sewage, Healthy Waters Campaign | [9] Bowmer, K.H. (1987) Nutrient removal from effluents by an artificial wetland: influence of rhizosphere aeration and preferential flow studied using bromide and dye tracers. Water Research, vol. 21(5), (591-599). | [11] Steiner, G. R. and Watson, J. T. (1993), General Design, Construction and Operation Guidelines: Constructed Wetlands Wastewater Treatment Systems for Small Users Including Individual Residences: 2nd Edition, Tennessee Valley Authority, Tennessee (1-42). | [12] Burns, E. R., Marshall, C., (1965), Chemical Oxygen Demand, Journal WPCF, Vol. 37, (1716-1721). | [13] Nathanson, Jerry A. (2003). Basic Environmental Technology: Water Supply, Waste Management, and Pollution Control. Upper Saddle River, New Jersey | [14] Garcia, J. Morator, J. Bayona, J. M. and Aguirre, P. (2004), Performance of Horizontal Surface Flow Constructed Wetlands with Different Depths, Proc. 9th International Conference on Wetland Systems for Water Pollution Control, France (269-276). | [15] Payne, V. W. E. and Knight. R. L. (1998), New design procedures for animal waste constructed wetlands. ASAE Paper No. 982089, 1998 ASAE International Mtg., Orlando, FL, ASAE, St. Joseph,MI. | [16] Sawyer, C. N. and McCarty, P. L. (1967), Chemistry for Sanitary Engineers, 2nd ed. McGraw - Hill, New York. | [17] USEPA, (2000). Standard method for the examination of water and wastewater, standard method 330.5 | [18] INAP, (2006), Treatment of sulphate in mine effluent. International Network for Acid Prevention | [19] Allem C. J. L (1997), Treatment of sulphate –rich effluents with the sulphide process. MSc thesis. University of Pretoria, south africa | [20] World Health Organization. (2004), Background document for development of WHO Guidelines for Drinking-water Quality | [21] Self, J. R. and Waskom, R. M. (2013), Nitrates in Drinking Water. Colorado State University Soils Testing | [22] John Wiley & Sons, (1993), Aquatic Pollution. 2nd Ed. 1993. E.A. Laws., Inc., New York, NY. pp (148-149). | [23] Black, J.A. (1997). Water pollution technology. Reston Publishing Co., Reston, VA. | [24] Lessels, J. S., Bishop, T .F .A., (2013), Estimating water quality using linear mixed models with stream discharge and turbidity, Faculty of Agriculture and Environment, The University of Sydney, Sydney, NSW, Australia | [25] Elizabeth Myre & Ryan Shaw, (2006), Simple and Accurate Measurement of Turbidity in the Field. Michigan Technological University | [26] Nancy Mesner and John Geiger, (2010), understanding yout watershed,UtahState University. | [28] Alexandra M.E. Viana da Silva, Ricardo J.N. Bettencourt da Silva , M. Filomena G.F.C. Camões, (2011), Optimization of the determination of chemical oxygen demand in wastewaters, Faculty of Sciences, University of Lisbon, (1749-016) |