UTILIZATION OF WATER PLANTS AS MEDIA TO LOWER RAW WATER SALINITY CONSUMED BY PEOPLE IN SOUTH KALIMANTAN

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ABSTRACT

Water is natural resource that is essential for life of all living things. Problems frequently encountered are the limited availability and difficulty to get clean water especially during dry season. One of the other problems is the high level of salt content (salinity) in most water consumed as a result of sea water intrusion. The objective of this research is to study the utilization of plants found on aquatic land or swamp land in the region of South Kalimantan as the media of reducing salt content in raw water sources for consumption water which is processed in installation of clean water. Plants used among others are water hyacinth (*Eichhornia crassipes*), giant salvinia (*Salvinia molesta* D. Mitch), water lettuce (*Pistia stratiotes*, Linn) and chinese water chestnut (*Eleocharis dulcis*). The research was conducted by using Completely Random Design (CRD) by putting the four plants each on a container filled first with salt solutions in concentration 1% (equivalent to 10,000 ppm). The time of observation was done on 7 days, 14 days and 21 days to identify the content of salt absorbed by and the effect on the plants. The data were analyzed using anova and were tested further using DMRT on 5% standard. The result showed that all water plants used were able to absorb salt in solution and reduce the salinity in different levels of the salt absorption. It was indicated that the content of salts had different between the top of the plants (the stalks and leaves) and the roots, the concentration of salt in the roots was larger. The test results indicated that up to 21 days observation, the absorption of salts upon chinese water chestnut, water hyacinth, water lettuce and giant salvinia, sequencially were : 5400 ppm (roots) and 2400 (stalks), 5216 ppm (roots) and 2700 (stalks), 3200 ppm (roots) and 1911 ppm (stalks) and also 4125 ppm (roots) and 1700 ppm (stalks).

Key words : Salinity, water plants, South Kalimantan

INTRODUCTION

Water is the most essential substance in everyday life apart of oxygen. About three-quarters part of human body consists of water and no one can survive more than 4-5 days without drinking water. The volume of water needed by each individual per day is about 150-200 liters or 35-40 gallons. It varies depending on the climate, living standards, and customs of the people. Water is also used for industrial purposes, agriculture, firefighting, recreation, transportation, sanitation and others.

So dependent Human life is on the water, therefore the quality of human life depends on the quality of water consumed. Good and healthier water makes healthy and well preserved ecosystem, so that at the end makes people more prosperous. Conversely, poor water quality gives impact on environmental degradation.

Most of the water, approximately 97 % is available in the ocean or sea, and the salt content is too high for most purposes. 3% of the remaining, almost all of them, approximately 87 % are stored in the polar layers or very deep under the ground .

Sea water intrusion

The problem often encountered by people living in the area near the coast is the issue of high salt level in the well water or consumption water of those obtained from the local water company. As an example of such a case is that occurred in Banjarmasin, South Kalimantan. The salinity of rivers in South Kalimantan in the dry season is still high due to sea water intrusion. In Martapura River and the Barito River, the salinity reaches 8,800 mg / liter, higher beyond the quality standard of a maximum of 250 mg / liter . Even at the peak of dry season some time ago, the level of salt content in the Barito River reached 15,000 mg / liter or equal to sea water salinity. As a result of the intrusion of sea water, fresh water production produced by Regional Water Company of Banjarmasin declined by 50 % from normal conditions, which reaches 2,000 liters / second.

Saltwater intrusion is the movement of saltwater into freshwater aquifers that can contaminate drinking water sources. Saltwater intrusion can occur naturally to some degree in most coastal aquifers due to the hydraulic relationship between groundwater and seawater, because saltwater has a higher mineral content than freshwater, therefore sea water has a higher density and greater water pressure, so that the brine moves towards freshwater (Johnson, 2007).

Various human activities, especially groundwater pumping from coastal aquifers, may increase intrusion of sea water because groundwater pressure is reduced and becomes relatively lower than the seawater pressure.

Other causes of saltwater intrusion is navigation and drainage canals that creating an opening for sea water moving inland across the surface and through the tide (Barlow, 2003). Intrusion of sea water can also occur in extreme weather conditions such as storms and larger waves.

Construction of canals and drainage can lead to saltwater intrusion. Canals provide an opening for salt water to get to the mainland. Drainage network built to drain water from coastal residential areas can be trigger of intrusion by lowering the freshwater level. The main causes of water intrusion is the decrease of water level. In addition, the construction process and the availability of canal made sea water flowing into the mainland until the construction of sluice control (Barlow and Reichard, 2010)

There is one environmental problems faced by the people who live on the coastal area in Indonesia, the intrusion of sea water .

Factors that lead to sea water intrusion are namely :

1. The exceeding capacity of groundwater uptaking;
2. The pruning of mangrove forests on the coast;
3. The Global warming;
4. The decrease of ground water level as a result of geological processes (shifting of tectonic plates).

The impact of sea water intrusion are among others can be stated as the following : first, the availability of clean water is more limited, because the ground water is contaminated with sea water, so it tastes salty; second, the farm around the coast will loss due to the limited stock of fresh water for irrigation; third, the health of people around the coast deteriorates due to the lack of groundwater consumption .

Water plants in South Kalimantan

Water Hyacinth (Eichhornia crassipes)

Water hyacinth is one of floating aquatic plant species, grows in shallow ponds, wetlands and swamps, slow water flow, lakes, reservoirs and rivers. This plant can adapt to extreme changes of the high water level, water flow, and changes in nutrient availability, pH, temperature and toxins in water. Water hyacinth has the ability to reduce the content of BOD, COD, NH_3, phosphate, and suspended solids which are benchmarks of pollution by organic substances (Suardhana, 2009).

Water hyacinth is able to absorb various substances contained in the water, either dissolved or suspended. The speed of Water Hyacinth in absorbing pollutants in wastewater is influenced by several factors, including the composition and concentration of substances contained in wastewater, the density of Water Hyacinth, and lifetime of Water hyacinth in the wastewater.

The ability of Water hyacinth as a bio-filter is due to the microbial rhizosfera in the roots and it is supported by the large adsorption and large accumulation of certain pollutants (Marianto, 2001).

Figure 1. Water Hyacinth

Giant Salvinia (*Salvinia Molesta* D. Mitch)

Giant salvinia is a common name for the genus Salviniales. This plant is commonly found floating in the stagnant water, such as ponds, fields and lakes, or rivers flowing quiet. Giant salvinia is one of plant of phytoremediator for heavy metals Cd and Cr contained in wastewater (Sudibyaningsih, 2004), and is able to adapt to environments of low salinity conditions (< 10 ‰) (Biber , 2008) .

Selection of Giant salvinia as phytoremediator plants in several studies is based on some considerations that S. molesta is able to grow in low nutrient waters (Room and Julien, 1995 cit . Dhir, 2009). Apart of this, morphologically S. Molesta has relatively small diameter leaves (on average 2-4 cm) but has dense and long roots (Oliver, 1993). Based on this, it is expected that S. Molesta can effectively absorb pollutants, but does not block the penetration of light into the water.

Figure 2. Giant salvinia

Water Lettuce (*Pistia Stratiotes*, Linn)

Water lettuce is an aquatic plants usually found floating in calm waters or pools and is also popular as an aquarium plant protector. The substance contained in water lettuce is pelifenol, flavonoids, and tannins. water lettuce plants has efficacy as an anti-rheumatic, anti-inflammatory, urinary laxative (diuretic) and anti skin diseases and eczema. Besides having the benefit of the treatment, the plants water lettuce can also maintain the quality of the water as it absorbs pollutants or toxins. These plants are useful especially when the hapa system is done on nusery of fish so that the fish larvae are isolated from predators .

Studies done such as by Taufik (2003) examined the absorption of Cr by plant lettuce, the amount of water lettuce used was as much as 50 grams in 1 liter of solution Cr 20 ppm, and the absorption time was 6 days, the Cr content could be lowered to 97. 29 %. Water lettuce was selected as a bio-filter used in the study because these plants have the advantage that it has much roots and is easily cultivated.

Figure 3. Water lettuce

Chinese Water Chestnut (*Eleocharis Dulcis*)

Chinese water chestnut is wild plant that is well adapted to the sulfate acid tidal swamp land. This plant has many benefits. The tubers juice contain puchiin antibiotics that are effective against *Staphylococcus aureus*, *Escherichia coli*, and *Aerobactery aerogenes*. In Indonesia, stems of chinese water chestnut are used to make mats (Wardiono, 2007) and as animal feed especially for swamp buffaloes as in the village of Pandak Daun, South Kalimantan (Hardiansyah, 1995).

Figure 4. Chinese Water Chestnut

Chinese water chestnut is a trap crop for white rice stem borer and the habitat for several types of natural enemies such as predators and parasitoids (Asikin et al. 2001). Another function is as a source of organic material and bio-filters that are able to absorb toxic elements or heavy metals such as iron (Fe), sulfur (S), mercury (Hg), lead (Pb), and cadmium (Cd) (Asikin and Thamrin 2011).

Priyatmadi et al. (2006) states, chinese water chestnut vegetation can grow in soil with a pH of 3 and a content of exchangeable aluminum (Al dd) 5,35 me / 100 g, the high content of soluble sulfates (0.90 me / 100 g), and the content of soluble iron 1.017 ppm. Thus it can be said that chinese water chestnut can grow in poor soil conditions.

Chinese water chestnut can be used as a biofilter to improve water quality in the dry season by absorbing soluble toxic compounds such as Fe and SO in water channels/inlets (irrigation) and drain out water/outlets (drainage) (Indrayati, 2011).

Based on problems about the impact of seawater intrusion that occur in several regions including in Banjarmasin, South Kalimantan, it is important then to search and research the solutions. One of the ways to reduce salinity levels in the raw water to be processed by the installation into consumption water is phytoremediation to reduce salt content using some kind of aquatic plants that are widely available in South Kalimantan region such as Water Hyacinth, Giant salvinia, Water lettuce and Chinese water chestnut.

MATERIALS AND METHODS

A. Materials and Equipment

The materials used in the study were water plant of water hyacinth (*Eichhornia crassipes*), giant salvinia (*Salvinia molesta D.* Mitch), water lettuce (*Pistia stratiotes*, Linn) and chinese water chestnut (*Eleocharis dulcis*), NaCl, distilled water, 5% solution of K_2CrO_4 and solution of 0.1 M $AgNO_3$. The tools used were among others mortars, porcelain crucibles, analytical balances, knives, Erlenmeyers, burettes, funnels, desiccators, an oven, paper labels and stationery.

B. Method of research

The research was conducted using Completely Random Design (CRD) by putting the fourth plants each on a container of 10 kg capacity that had been filled out of salt solutions by concentration of 1% (equivalent to 10,000 ppm), three replicants for each treatment, and the observation time was 7 days, 14 days and 21 days to identify the salt content absorbed and its effect on the plants. The data were Analyzed using ANOVA and were tested further using DMRT on 5 % standard.

Working procedures

1. The samples of 5 grams each plants were wighed and burnt to be ash.
2. The ash then was washed with distilled water as little as possible and transferred into a 250 ml Erlenmeyer flask.
3. 1 ml K_2CrO_4 5 % was added and titration with $AgNO_3$ 0.1 M (standardized) was done up to the orange color or first orange color observed.
4. The salt content or salinity was calculated by the formula :

$$\text{NaCl (\%) content} = \frac{\text{T x M x FK x FP}}{\text{W}} \times 100\%$$

Notes :

T = Volume of titer (ml)
M = Molarity of $AgNO_3$
FK = Correction Factor
FP = Dissolving Factor
W = Weight of Samples (mg)

RESULTS AND DISCUSSION

Salinity problems encountered in residential areas adjacent to coastal areas is an obstacles faced by people who live in the region. Intrusion of sea water as the main cause salinity problems, especially during the dry season can not be prevented that the needs of clean water for society consumption purposes can not be realized. Water companies also find difficult to process clean water not because of the amount of water that is slightly, but the high level of water salinity is feared would damage the processing tool on the installation of clean water.

One of the efforts to overcome this is to use phytoremediation technique that makes the water plants having function as means of bio-filter and bio-accumulator to absorb high levels of salt so that the water resulted from the treatment of phytoremediation has a salt content not exceeding the threshold to be processed into clean water.

Phytoremediation is the effort of using plants to reduce the concentration of waste and environmental pollution problems either ex-situ using artificial ponds or reactors or in-situ (on the field) on land or waste contaminated waters (Soetrisnanto et al. 2012). The waste water will be processed is planted with certain plants that are able to absorb, accumulate and degrade specific pollutants contained in the waste water. The plants can filter, adsorb organic particles and absorb metal ions contained in the waste water by means of the roots (Safitri 2009).

Basically, all types of water plants are able to absorb heavy metals in root tissues and can be used as a biological filter or just used as an indicator of pollution (Palar, 2004).

Biological wastewater treatment plant by bio-filtration using water plants as absorbent media is more widely used. Bio-filtration has several advantages including effective, low budget in building the bio-filtration ponds, fast-growing trees and easy to maintain, does not require operators having special expertise, as well as this method is eco-friendly (Ulfin. 2001).

Results of research data analysis on the utilization of some water plants to reduce salt in water sources that will be processed into water consumption in water treatment plants shows that there are significant differences among the four types of plants to absorb the salt content either on the shoots or roots (Table 1). On the shoots, the salinity absoption respectively for chinese water chesnut 2400 ppm, water hyacinth 2700 ppm, water lettuce 1911 ppm and giant salvinia 1700 ppm. While on roots, the salinity absoption respectively for chinese water chesnut 5400 ppm, water hyacinth 5316 ppm, water lettuce 3200 and giant salvinia 4125 ppm. The absorption of salt in the roots is greater than in the plant shoots. This is because the roots are the first organ that absorb the substance or material from around the growing or planting media, so that the accumulation of the salt content is more concentrated in that part of the plant as compared to the salt concentrations found in the shoots, it is because the concentration of salt in the shoots is a series of metabolic process of plants transport.

Table 1. Absorption of salt content (ppm) in various types of water plants of 21 days after treatment

Types of plants	Shoots	Roots
Chinese water chesnut	2400 b	5400 a
Water hyacinth	2700 a	5316 b
Water lettuce	1911 c	3200 d
Giant salvinia	1700 d	4125 c

Notes : figures of one collumn followed by same leters have no significant difference according to DMRT at α = 5 %

According to Fitler and Hay (1991), it happened because the roots are directly in contact with waste water and sediments located at the bottom of the water. In addition, there is an attempt to localize the toxic materials that go into the plants so as to prevent intoxication and expedite the process of metabolism and the metal can be bound by chelate molecules. The roots produce peptide compounds namely fitokelatein more than the leaves. In plants, most of these metals will be saved in the vacuole and partly bound by fitokelatein .

Based on the means of experimental data after the observation on day 21, it is shown that the absorption ability of water hyacinth has accumulated the largest salt levels followed successively by chinese water chestnut, giant salvinia and water lettuce. Water hyacinth was known to be a sound bio-accumulator and bio-filter especially against the pollution of heavy metals and toxic compounds either in the form of organic or non-organic compounds. Chinese water chestnut, water lettuce and giant salvinia are also good bio-accumulator plants and relatively resistant to salt content in a concentration of up to secondary level, while for the water hyacinth, the growth and metabolism process is inhibited in high salinity.

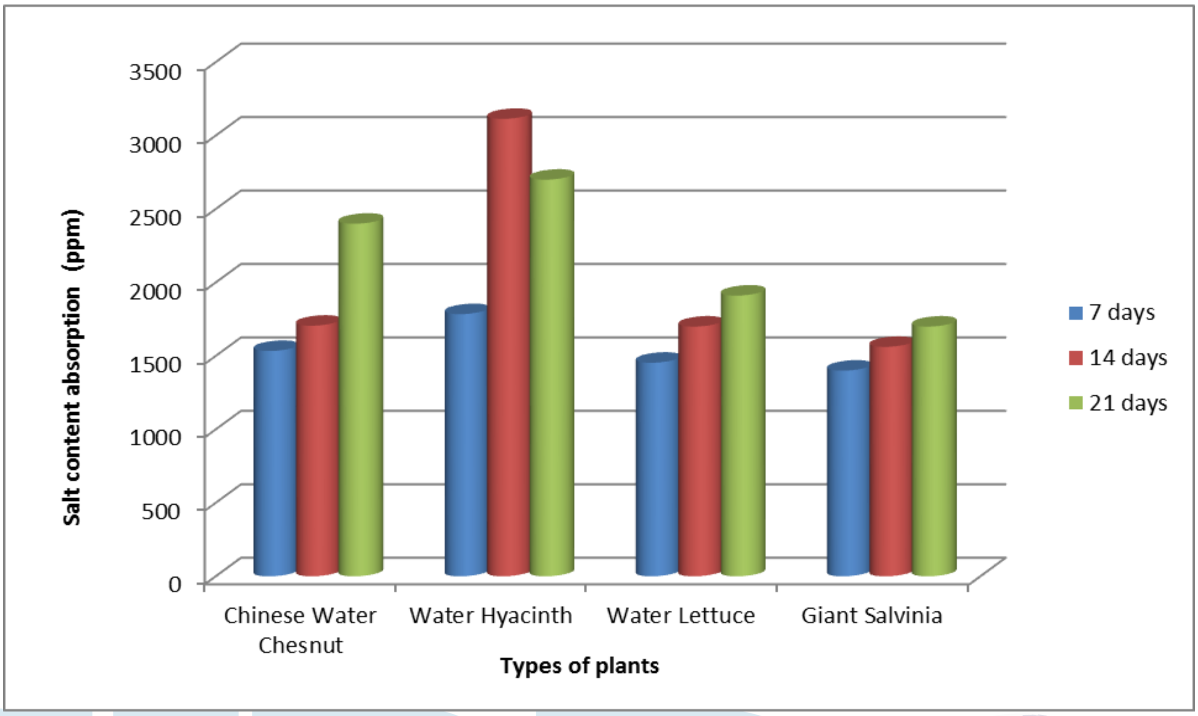

Figure 5. Histogram of salt content absorption (ppm) in various parts of the test plants shoot

Over three times of observation period, histogram absorption of salinity on plant shoots showed that the absorption of dissolved salts was gradually increased as time went by in Purun Tikus and Wood Lettuce Kiambang. However the accumulation of salt content because of the absorption process by Water Hyacinth increased up to the observation day 14 and decreased on day 21 although it was still a greater value than the three other plants.

It showed that the Water Hyacinth did the mechanism of limiting the amount of salt went into the shoots section due to the possibility of the ability to accommodate salt up-taken had exceeded the critical point and would disrupt the metabolic processes in the plant. Water Hyacinth had the greatest ability as accumulators of pollutants and heavy metals, thus the increasing levels of pollutants including salt levels that were too high could kill cells which consequently disrupted the biochemical processes of Water Hyacinth .

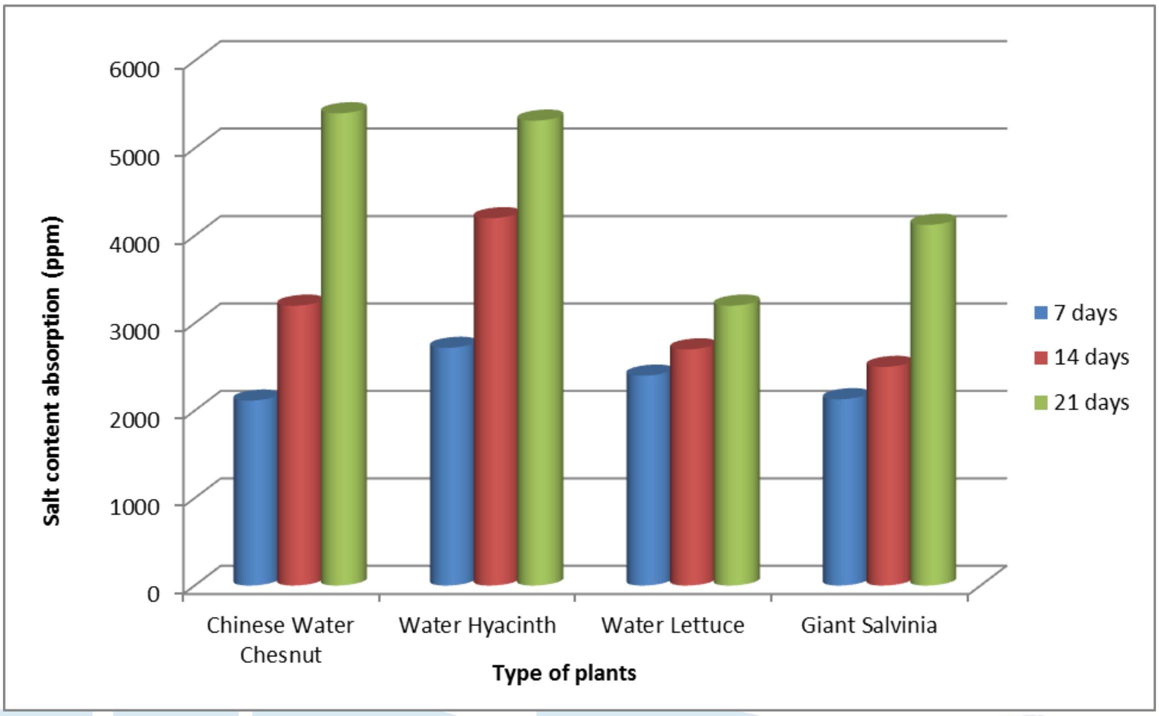

Figure 6. Histogram of salt content absorption (ppm) in various parts of the test plants roots

Histogram absorption of dissolved salts in the roots was different from the shoots. In roots of the all four types of plants, until the 21st day observations showed that absorption levels of salt were still ongoing and more increasing. Water Hyacinth and Purun Tikus accumulated salt absorption greater than Kayu Apu and Kiambang. This could be caused due to the Water Hyacinth plant morphology and Purun Tikus is bigger so that the roots can reach a wider area with greater absorption power of salt solution.

Phytoremediation carried-out in this study can be applied to reduce salt levels in the raw water source will be processed into water for public consumption. The application can be done by adding the bio-accumulator plants into the water storage tanks of high salinity so that the plants can absorb the salt and reduce the salinity level of the water. Based on the results of the research, it can be concluded that the four species of plants can absorb the salt with different absorption rate and the absorbed salt will be accumulated in the root. Test results shows that the absorption levels of salts upon Chinese Water Chestnuts, Water Hyacinth, Wood Lettuce and Kiambang are sucessively: 5400 ppm (root) and 2400 ppm (shoot), 5216 ppm (root) and 2700 ppm (shoot), 3200 ppm (root) and 1911 ppm (shoot) and also 4125 ppm (root) and 1700 ppm (shoot) up to 21 days observation.

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