



The Potency of *Ludwigia adscendens* and *L. octovalvis* as Phytoremediator Macrophytes in Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors Author RA prepared and completed the manuscript. Author RAMS with an idea of selecting these species to review and she initiated the writing. Author DR oversaw the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The potency of *Ludwigia adscendens* and *L. octovalvis* as phytoremediator macrophytes in Indonesia was reviewed. The characteristics of these species might be essential information for operators who wanted to implement phytoremediation in their sites. Information and articles about these species in Indonesia was collected through Google-Scholar during the first week of February 2021 and reviewed. Many studies about phytoremediation focused only on the capabilities of macrophytes to remove contaminants from water and paid only little attention to their compatibility with the ecosystem leading to upset the ecosystem. To Indonesia, these two species were introduced and became weeds, with different ecological characteristics. In Indonesia, scarce phytoremediation studies using these species were detected. Therefore, although these species were classified as weeds it was, remained, worthwhile to investigate further these species to be used in the phytoremediation of water.

Keywords: *Macrophyte; accumulator; weed; rooted-floating.*

1. INTRODUCTION

It is a common knowledge that phytoremediation applications always focus on the end results only and with little attention to the characteristics of the plants. Various plants were compared and studied to determine which ones were the most effective in reducing contaminants from water or soils. For example, a study conducted by Dewi et al. [1] which used two macrophytes namely *Pistia stratiotes* and *Lemna* sp. to treat wastewater from tofu industries. The study showed better results which these species could increase dissolved oxygen and remove some nutrients. However, these two species are well-known as weeds and invasive species which may upset the water-body ecosystem equilibrium. Obviously, a phytoremediation research is expected to be applied in fields so that the compatibility of species to the local ecosystem must be the main consideration so as not to damage the ecosystem when results of phytoremediation are applied [2-4]. This is where the user or operator's discretion in determining which plant species will be applied in the field. On the other hand, researchers are also required to be more diligent in selecting plants that are suitable for the local ecosystem in order to make it easier for users or operators to choose phytoremediation plants. If it is not necessary that the native species from the local ecosystem are used in the phytoremediation research, then information on the distribution of the plant species should be described in their research articles.

This article is a literature review of two macrophytes, namely *Ludwigia adscendens* and *L. octovalvis*, which elaborates their potential as phytoremediation plants in Indonesia.

2. PLANT SUITABILITY FOR PHYTOREMEDIATION

Many considerations are used in determining the phytoremediation plant species. From now on, apart from the best capability of plants in reducing contaminants from the media, the suitability of plants to the local ecosystem should be taken so that phytoremediation plants do not shift the ecosystem balance [5,6]. Moreover, Delgadillo-López et al. [6] emphasised to incinerate the fully-grown phytoremediators to avoid exotic species spread. Based on these, at least 2 (two) main considerations in determining phytoremediation research plants: 1) The capability of the species as phytoremediator and 2) Distribution or nativity of the species.

2.1 The Capabilities of *Ludwigia adscendens* (L.) H. Hara

As noted by *cabi.org* [7] *L. adscendens* is the most used common scientific name, although this species has several synonyms, such as *Jussiaea repens* L., *Jussiaea diffusa* Forsk., *Jussiaea stolonifera* Guill. & Perr., *Ludwigia natans* (L.) Ell. In Indonesia, this species is also known by various local names such as *dadangsit* from South Kalimantan Province [8], *krangking* from Purwodadi, Central Java Province, *krokot membulat* from Bekasi, West Java [9] *tapak dara air* from East Java Province [10] (Fig. 1). According to its type, *L. adscendens* is included in the type of aquatic plants or macrophytes which leaves float and are rooted at the base of wetlands or sediments (Floating leaf plant-FLP) [11], the process of vegetative growth occurs throughout the year, while flowering and fruit formation occurs at the beginning of the rainy season for 4-5 months [12].



Fig. 1. *L. adscendens* with Five White Petals and Yellow Color at the Base

Source: <https://worldoffloweringplants.com/ludwigia-adscendens-water-primrose/>

From its habitus, *L. adscendens* is suitable for use in phytoremediation because the role of its roots is significant. In the substrate, the roots supply oxygen for the living things in it, which in turn, may activate and accelerate the phytoremediation process. In addition to providing life for living things, the diffusion of oxygen in the substrate may stimulate the precipitation of metals in the sediments [13]. With a little modification, it is expected that the roots of *L. adscendens* can float in the water column so that its function as a metal absorber is maximized.

Caution should be taken when this species is used in phytoremediation because of the potential to spread mosquitoes by attaching mosquito larvae [14] and snails [15] to the stems and leaves of *L. adscendens* into new habitats.

In fact *L. adscendens* is better known and widely studied as a pharmaceutical raw material or for medication [16]. For example, research conducted by Ahmed et al. [17] and Lwin [18] used this species as an antibacterial agent, by Krishnappa et al. [19] as a mosquito repellent, by Al-douri [20] and Yan et al. [21] as a medicine for ulcers and itching on skin, by Das, Ghosal, Chakraborty, and Pradhan [20] as an anemia medicine, by Khandekar et al. [22] for diabetic medication.

In the phytoremediation application of contaminated water, *L. adscendens*, especially in Indonesia, is still not widely implemented, although its potential to treat wastewater has been predicted. Baroroh and Irawanto [23] have identified 18 macrophytes in the Purwodadi Botanical Garden, Central Java Province and one of them is *L. adscendens*, which was thought to have an ability to treat domestic liquid waste through phytoremediation techniques. Xu et al. [4] concluded that *L. adscendens* was performed better than *Eichhornia crassipes* which was trusted as the best phytoremediator for domestic wastewater.

In India, *L. adscendens* is classified as weed [24] and in their research, Khankhane and Varshney [24] had identified the capability of *L. adscendens* in phytoremediation which accumulated Ni, Cu, Fe, and Zn as much 17, 57, 1,878, and 155 µg/g (dw/dw), respectively, in the biomass. In that study, 18 plants were tested, and *L. adscendens* was included in the first 5 (five) species that had the highest capability in removing the four metals. In relation to Fe and

Cu, *L. adscendens* took second place after *Convolvulus arvensis* and *Mullugo verticillata*, respectively.

Against other heavy metals, Cd, Cu, Cr and Pb, it turned out that *L. adscendens* had a higher capability to remove Cr from water bodies than other the tested heavy metals [25]. From Illinois-America, Larson and Sims [26] managed to detect the ability of this plant in the removal of atrazine (C₈H₁₄C₁N₅), which is a persistent compound, up to 50% within 6-7 days. While at Hartbeespoort Dam in the North West Province of South Africa, *L. adscendens* succeeded in absorbing cyanotoxin which was toxic and was produced by a type of cyanobacteria that was often found in water bodies [27].

The phytoremediation studies on *L. adscendens* in Indonesia are scarce and the studies have just started since early 2010. Its adaptability in habitats contaminated with Cd has been studied by Rachma [28] and published in a national journal by Rahma et al. [29]. After that, several phytoremediation studies were carried out to remove Cd [30,31,10] and Pb from *Lapindo* mud in East Java Province [32]. Rachmadiarti et al. [30-31] used several macrophytes, one of which is *L. adscendens* to remove detergents in Surabaya city, and proved the species could reduce detergent from the wastewater. Although there have not been many studies on this species, but it has given sufficiently an indication of its capability to remove metals and organic compounds from wastewater of from water bodies.

2.2 The Capabilities of *Ludwigia octovalvis* (Jacq.) Raven

In Indonesia *L. octovalvis* is known by several local names such as: *Salah nyowo* from Purwodadi, Central Java Province [23] *bunga kuning* from Bekasi, West Java Province [9] *cecabean* from Ogan Ilir, South Sumatra Province [9].

L. octovalvis is an emergent macrophyte which stems and leaves are above the water surface while the roots are in the sediment [11]. Hidayati and Rini [9] who are researchers at the Centre for Biological Research-Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia* - LIPI), found that *L. octovalvis* is a bioaccumulator for Cd. Apart from Cd, several studies such as, Titah et al. [33-34], Rajoo et al.

[35] have proven that *L. octovalvis* may remove As, Pb [36], Hg [37] from contaminated media.

Al-Mansoori et al. [38] Alanbary et al. [39] Alanbary et al. [40] Alanbary et al. [41] in their studies also concluded that *L. octovalvis* is quite tolerant of hydrocarbons and is able to break down hydrocarbons from contaminated media. The process of breaking down and decreasing TPH by *L. octovalvis* can be accelerated and increased by the addition of bio-surfactants [42].

Similar to *L. adscendens*, research on *L. octovalvis* as a medicinal ingredient [43,44] has also been widely carried out. Chang et al. [45] examined this plant for cancer medicine, Aung and Chaw [46] examined its leaves as an antibacterial/microbial material, Lin et al. [47] examined as a diabetes treatment ingredient. Moreover, the use of *L. octovalvis* is known to be safer than *L. adscendens*, which may cause allergic effects on the skin [48].

2.3 Distribution *L. adscendens* in Indonesia

According to Mallick et al. [44] this species originates (nativity) from the Tropical America region. In Indonesia, *L. adscendens* is better known as *tapak dara air* and its existence has

been scientifically identified since 1979 by Holm, Pancho, Herberger, and Plucknett [49]. Based on several scientific studies on phytoremediation using this species, which was recently implemented in the early 2010s, it is known that its distribution is in the Purwodadi-Central Java Province and Surabaya-East Java Province.

Known as weed, *L. adscendens* distribution has been identified in Malang, East Java Province [50] Sragen Regency, Central Java Province [51] Cangkiran Village, Mijen District, Semarang City, Central Java Province [52] Hulu Sungai Utara Regency and Hulu Sungai Selatan Regency in South Kalimantan Province [8].

This species is also considered as a weed in India [53] and even in Bangladesh [16]. Nevertheless, although it is a weed, *L. adscendens* is less invasive. Observations made by Chakraborty [16] in the wetlands of Netrokona and Sunamgonj, North Bangladesh indicated a three-year decline in the *L. adscendens* population due to human activities. Purnomo [52] states that *L. adscendens* tends to die after its reproductive period. This species has less adaptation capability to the significant change of environment, for example, the change from wet, such as rice fields, to dry media is enough to kill it [8].



Fig. 2. *L. octovalvis* with Four Yellow Petals but the Stem and Sepals are Red

Source: <https://www.dineshkhedkar.co.in/mpdb/record.php?act=view&id=MS054>

2.4 Distribution *L. octovalvis* in Indonesia

According to Sainkhediya and Sisodiya [54] *L. octovalvis* originated (nativity) from the Tropical Africa. This was different from the publication of Mallick et al. [44] which stated the origin of this species is Tropical America. However, both of them have in common that they both came from the tropics. Nevertheless, its current distribution in the literature review by Liu et al. [55] and by looking at its genetic information done by Liu et al. [56] concluded that this species has spread throughout the world and is an invasive weed species. In Mexico, *L. octovalvis* is commonly found in wetlands and is a weed [43] and in India as well which may threaten to biodiversity of the wetlands [57]. For *L. adscendens*, *L. octovalvis* is more invasive, which was concluded from observations in lakes in Baiyun and Caohai, China by Xiao [11]. Therefore *L. adscendens* was more recommended for phytoremediation although it is known that this species might potentially spread mosquitoes. With or without *L. adscendens*, mosquitoes spread freely and widely because they can fly. On the other hand, *L. adscendens* could spread mosquitoes through their larvae, but the attached mosquito larvae on the *L. adscendens* might not be survived in its new environment.

In Indonesia, *L. octovalvis* is considered as weed, especially in agricultural fields and needs to be intensively controlled. If the effect of metsulfuron methyl herbicide to suppress broadleaf weeds in rice fields has disappeared, then *L. octovalvis* may return [58]. However, a weed research in Philippines conducted by Chauhan and Abugho [59] showed different conclusion which *L. octovalvis* growth was suppressed by paddy (*Oriza sativa*). *L. octovalvis* adapted to the *O. sativa* interference by applying its plasticity capability by reducing the size of shoot parts of the plants. In other words, *L. octovalvis* might not inhibit significantly *O. sativa* growth but the presence of *L. octovalvis* could reduce the nutrient availability in the media.

In a study of the phytoremediator in the Purwodadi Botanical Garden, *L. octovalvis* was also found together with *L. adscendens* [5,60]. Its potency in maintaining the water quality in Cisadane River, West Java Province and in Karawang-Bekasi has also been noted by Siahaan [61] and Hidayati and Rini [9] respectively. As a rice weed, *L. octovalvis* has been identified as being found in Ogan Ilir

Regency, South Sumatra Province [9] Sigi Regency, Central Sulawesi Province [62] Malang, East Java Province [50] Sragen Regency, Central Java Province [51].

However, some parts of Indonesia these species has not been found. For examples, the results of an inventory of macrophytes in Embau River, Hulu Gurung District, Kapuas Hulu Regency, West Kalimantan Province, the two species have not been identified [63] as well as in the wetlands of Rawa Village, Kampar Regency, Riau Province [64-66].

3. CONCLUSION

In Indonesia, these two species have not been widely studied in phytoremediation, although their existence has been identified in scientific publications since 1979. Research on these two species as phytoremediators has only started a decade earlier. Therefore it is worth examining their ability for phytoremediation applications in Indonesia.

L. adscendens was more widely used in phytoremediation studies than *L. octovalvis*. Based on this situation, more phytoremediation studies using *L. octovalvis* were recommended. It was also suggested to use COD and BOD parameters in water phytoremediation studies because these two parameters had not been used to measure the effectiveness of a phytoremediation using these species.

For areas in Indonesia where these two species have not been found, it is recommended not to use this species for phytoremediation because they were weeds and exotics to Indonesia. However, comparing these two species, *L. adscendens* was less invasive than *L. octovalvis*, so *L. adscendens* was more preferred to be used with a strict control measures to ensure it did not escape into nature, if there was no phytoremediator options available.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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