

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

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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. (2019) which used two macrophytes namely *Pistia stratiotes* and *Lemna* sp. to treat wastewater form 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 (Nash et al., 2019; Leguizamo et al., 2017; Xu et al., 2020). 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.

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

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## 2. PLANT SUITABILITY FOR PHYTOREMEDIATION

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Many considerations are used in determining the phytoremediation plant species. From now  
42 on, apart from the best capability of plants in reducing contaminants from the media, the  
43 suitability of plants to the local ecosystem should be taken so that phytoremediation plants  
44 do not shift the ecosystem balance (Baroroh & Irawanto, 2016; Delgadillo-López et al.,  
45 2011). Moreover, Delgadillo-López et al. (2011) emphasised to incinerate the fully-grown  
46 phytoremediators to avoid exotic species spread. Based on these, at least 2 (two) main  
47 considerations in determining phytoremediation research plants: 1) The capability of the  
48 species as phytoremediator, and 2) Distribution or nativity of the species.

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

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As noted by cabi.org (2019), *L. adscendens* is the most used common scientific name,  
52 although this species has several synonyms, such as *Jussiaea repens* L., *Jussiaea diffusa*  
53 Forsk., *Jussiaea stolonifera* Guill. & Perr., *Ludwigia natans* (L.) Ell. In Indonesia, this species  
54 is also known by various local names such as *dadangsit* from South Kalimantan Province  
55 (Rostini et al., 2014), *krangking* from Purwodadi, Central Java Province, *krokot membulat*  
56 from Bekasi, West Java (Hidayati & Rini, 2017), *tapak dara air* from East Java Province  
57 (Rosyada & Purnomo, 2018) (Fig. 1). According to its type, *L. adscendens* is included in the  
58 type of aquatic plants or macrophytes which leaves float and are rooted at the base of  
59 wetlands or sediments (Floating leaf plant-FLP) (Xiao, 2018), the process of vegetative  
60 growth occurs throughout the year, while flowering and fruit formation occurs at the  
61 beginning of the rainy season for 4-5 months (Dutta & Sarma, 2018).

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

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

66 From its habitus, *L. adscendens* is suitable for use in phytoremediation because the role of  
67 its roots is significant. In the substrate, the roots supply oxygen for the living things in it,  
68 which in turn, may activate and accelerate the phytoremediation process. In addition to  
69 providing life for living things, the diffusion of oxygen in the substrate may stimulate the  
70 precipitation of metals in the sediments (Babcsányi et al., 2017). With a little modification, it  
71 is expected that the roots of *L. adscendens* can float in the water column so that its function  
72 as a metal absorber is maximized.

73 Caution should be taken when this species is used in phytoremediation because of the  
74 potential to spread mosquitoes by attaching mosquito larvae (Vythilingam et al., 1992), and  
75 snails (Ashour et al., 2008) to the stems and leaves of *L. adscendens* into new habitats.

76 In fact *L. adscendens* is better known and widely studied as a pharmaceutical raw material  
77 or for medication (Chakraborty, 2014). For example, research conducted by Ahmed et al.  
78 (2005) and Lwin (2019) used this species as an antibacterial agent, by Krishnappa et al.  
79 (2020) as a mosquito repellent, by Al-douri (2000) and Yan et al. (2020) as a medicine for  
80 ulcers and itching on skin, by Das, Ghosal, Chakraborty, and Pradhan (2015) as an anemia  
81 medicine, by Khandekar et al. (2020) for diabetic medication.

82 In the phytoremediation application of contaminated water, *L. adscendens*, especially in  
83 Indonesia, is still not widely implemented, although its potential to treat wastewater has been  
84 predicted. Baroroh and Irawanto (2016) have identified 18 macrophytes in the Purwodadi  
85 Botanical Garden, Central Java Province and one of them is *L. adscendens*, which was  
86 thought to have an ability to treat domestic liquid waste through phytoremediation  
87 techniques. Xu et al. (2020) concluded that *L. adscendens* was performed better than  
88 *Eichhornia crassipes* which was trusted as the best phytoremediator for domestic  
89 wastewater.

90 In India, *L. adscendens* is classified as weed (Khankhane & Varshney, 2008), and in their  
91 research, Khankhane and Varshney (2008) had identified the capability of *L. adscendens* in  
92 phytoremediation which accumulated Ni, Cu, Fe, and Zn as much 17, 57, 1,878, and 155  
93 µg/g (dw/dw), respectively, in the biomass. In that study, 18 plants were tested, and *L.*  
94 *adscendens* was included in the first 5 (five) species that had the highest capability in  
95 removing the four metals. In relation to Fe and Cu, *L. adscendens* took second place after  
96 *Convolvulus arvensis* and *Mullugo verticillata*, respectively.

97 Against other heavy metals, Cd, Cu, Cr and Pb, it turned out that *L. adscendens* had a  
98 higher capability to remove Cr from water bodies than other the tested heavy metals (Shah,  
99 Rai, & Singh, 2015). From Illinois-America, Larson and Sims (2003) managed to detect the  
100 ability of this plant in the removal of atrazine (C<sub>8</sub>H<sub>14</sub>C<sub>1</sub>N<sub>5</sub>), which is a persistent compound,  
101 up to 50% within 6-7 days. While at Hartbeespoort Dam in the North West Province of South  
102 Africa, *L. adscendens* succeeded in absorbing cyanotoxin which was toxic and was  
103 produced by a type of cyanobacteria that was often found in water bodies (Pindihama &  
104 Gitari, 2017).

105 The phytoremediation studies on *L. adscendens* in Indonesia are scarce and the studies  
106 have just started since early 2010. Its adaptability in habitats contaminated with Cd has been

107 studied by Rachma (2013) and published in a national journal by Rahma et al. (2014). After  
108 that, several phytoremediation studies were carried out to remove Cd (Rachmadiarti &  
109 Sholikah, 2020; Rosyada & Purnomo, 2018) and Pb from *Lapindo* mud in East Java  
110 Province (Nandra & Purnomo, 2019). Rachmadiarti et al. (2020) used several macrophytes,  
111 one of which is *L. adscendens* to remove detergents in Surabaya city, and proved the  
112 species could reduce detergent from the wastewater. Although there have not been many  
113 studies on this species, but it has given sufficiently an indication of its capability to remove  
114 metals and organic compounds from wastewater of from water bodies.

## 115 **2.2. The Capabilities of *Ludwigia octovalvis* (Jacq.) Raven**

116 In Indonesia *L. octovalvis* is known by several local names such as: *Salah nyowo* from  
117 Purwodadi, Central Java Province (Irawanto, 2016), *bunga kuning* from Bekasi, West Java  
118 Province (Hidayati & Rini, 2017), *cecabean* from Ogan Ilir, South Sumatra Province  
119 (Haryanto, 2017).

120 *L. octovalvis* is an emergent macrophyte which stems and leaves are above the water  
121 surface while the roots are in the sediment (Xiao, 2018). Hidayati and Rini (2017), who are  
122 researchers at the Centre for Biological Research-Indonesian Institute of Sciences  
123 (*Lembaga Ilmu Pengetahuan Indonesia - LIPI*), found that *L. octovalvis* is a bioaccumulator  
124 for Cd. Apart from Cd, several studies such as, Titah et al. (2018), Rajoo et al. (2016) have  
125 proven that *L. octovalvis* may remove As, Pb (Idris et al., 2016), Hg (Marrugo-Negrete et al.,  
126 2016) from contaminated media.

127 Al-Mansoori et al. (2017), Alanbary et al. (2017), Alanbary et al. (2019), Alanbary et al.  
128 (2018) in their studies also concluded that *L. octovalvis* is quite tolerant of hydrocarbons and  
129 is able to break down hydrocarbons from contaminated media. The process of breaking  
130 down and decreasing TPH by *L. octovalvis* can be accelerated and increased by the addition  
131 of bio-surfactants (Almansoori et al., 2019).  
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134 Source: <https://www.dineshkhedkar.co.in/mpdb/record.php?act=view&id=MS054>

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

136 Similar to *L. adscendens*, research on *L. octovalvis* as a medicinal ingredient (Lobato-de  
137 Magalhães & Martínez, 2018; Mallick et al., 2019) has also been widely carried out. Chang  
138 et al. (2004) examined this plant for cancer medicine, Aung and Chaw (2019) examined its  
139 leaves as an antibacterial/microbial material, Lin et al. (2017) examined as a diabetes  
140 treatment ingredient. Moreover, the use of *L. octovalvis* is known to be safer than *L.*  
141 *adscendens*, which may cause allergic effects on the skin (Sharma et al., 2017).

142 **2.3. Distribution *L. adscendens* in Indonesia**

143 According to Mallick et al. (2019), this species originates (nativity) from the Tropical America  
144 region. In Indonesia, *L. adscendens* is better known as *tapak dara air* and its existence has  
145 been scientifically identified since 1979 by Holm, Pancho, Herberger, and Plucknett (1979).  
146 Based on several scientific studies on phytoremediation using this species, which was  
147 recently implemented in the early 2010s, it is known that its distribution is in the Purwodadi-  
148 Central Java Province and Surabaya-East Java Province.

149 Known as weed, *L. adscendens* distribution has been identified in Malang, East Java  
150 Province (Widyaningrum, 2015), Sragen Regency, Central Java Province (Sudhana et al.,  
151 2019), Cangkiran Village, Mijen District, Semarang City, Central Java Province (Purnomo,  
152 2011), Hulu Sungai Utara Regency and Hulu Sungai Selatan Regency in South Kalimantan  
153 Province (Rostini et al., 2014).

154 This species is also considered as a weed in India (Jayan & Sathyanathan, 2012), and even  
155 in Bangladesh (Chakraborty, 2014). Nevertheless, although it is a weed, *L. adscendens* is  
156 less invasive. Observations made by Chakraborty (2014) in the wetlands of Netrokona and  
157 Sunamgonj, North Bangladesh indicated a three-year decline in the *L. adscendens*  
158 population due to human activities. Purnomo (2011) states that *L. adscendens* tends to die  
159 after its reproductive period. This species has less adaptation capability to the significant  
160 change of environment, for example, the change from wet, such as rice fields, to dry media  
161 is enough to kill it (Rostini et al., 2014).

162 **2.4. Distribution *L. octovalvis* in Indonesia**

163 According to Sainkhediya and Sisodiya (2020), *L. octovalvis* originated (nativity) from the  
164 Tropical Africa. This was different from the publication of Mallick et al. (2019) which stated  
165 the origin of this species is Tropical America. However, both of them have in common that  
166 they both came from the tropics. Nevertheless, its current distribution in the literature review  
167 by Liu et al. (2016) and by looking at its genetic information done by Liu et al. (2017)  
168 concluded that this species has spread throughout the world and is an invasive weed  
169 species. In Mexico, *L. octovalvis* is commonly found in wetlands and is a weed (Lobato-de  
170 Magalhães & Martínez, 2018), and in India as well which may threat to biodiversity of the  
171 wetlands (Barua et al., 2017). For *L. adscendens*, *L. octovalvis* is more invasive, which was  
172 concluded from observations in lakes in Baiyun and Caohai, China by Xiao (2018).

173 In Indonesia, *L. octovalvis* is considered as weed, especially in agricultural fields and needs  
174 to be intensively controlled. If the effect of metsulfuron methyl herbicide to suppress  
175 broadleaf weeds in rice fields has disappeared, then *L. octovalvis* may return (Respati et al.,  
176 2015). However, a weed research in Philippines conducted by Chauhan and Abugho (2012)  
177 showed different conclusion which *L. octovalvis* growth was suppressed by paddy (*Oriza*  
178 *sativa*). *L. octovalvis* adapted to the *O. sativa* interference by applying its plasticity capability  
179 by reducing the size of shoot parts of the plants. In, other words, *L. octovalvis* might not  
180 inhibit significantly *O. sativa* growth but the presence of *L. octovalvis* could reduce the  
181 nutrient availability in the media.

182 In a study of the phytoremediator in the Purwodadi Botanical Garden,. *L. octovalvis* was also  
183 found together with *L. adscendens* (Baroroh & Irawanto, 2016; Hidayah et al., 2020). Its  
184 potency in maintaining the water quality in Cisadane River, West Java Province and in  
185 Karawang-Bekasi has also been noted by Siahaan (2012) and Hidayati and Rini (2017),  
186 respectively. As a rice weed, *L. octovalvis* has been identified as being found in Ogan Ilir  
187 Regency, South Sumatra Province (Haryanto, 2017), Sigi Regency, Central Sulawesi  
188 Province (Suwitra et al., 2017), Malang, East Java Province (Widyaningrum, 2015), Sragen  
189 Regency, Central Java Province (Sudhana et al., 2019).

190 However, some parts of Indonesia these species has not been found. For examples, the  
191 results of an inventory of macrophytes in *Embau River*, *Hulu Gurung* District, *Kapuas Hulu*  
192 Regency, West Kalimantan Province, the two species have not been identified (Jayadi et al.,  
193 2017) as well as in the wetlands of *Rawa Village*, *Kampar* Regency, *Riau* Province (Nasution  
194 et al., 2020).

### 195 **3. CONCLUSION**

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

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

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208 **COMPETING INTERESTS**

209

210 "We, the authors have declared that no competing interests exist in preparing this article."

211

212 **AUTHORS' CONTRIBUTIONS**

213

214 Authors may use the following wordings for this section: " Amin prepared and completed the  
215 manuscript. Sari came with an idea of selecting these species to review and she initiated the  
216 writing. Rahyuni oversaw the manuscript.

217

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